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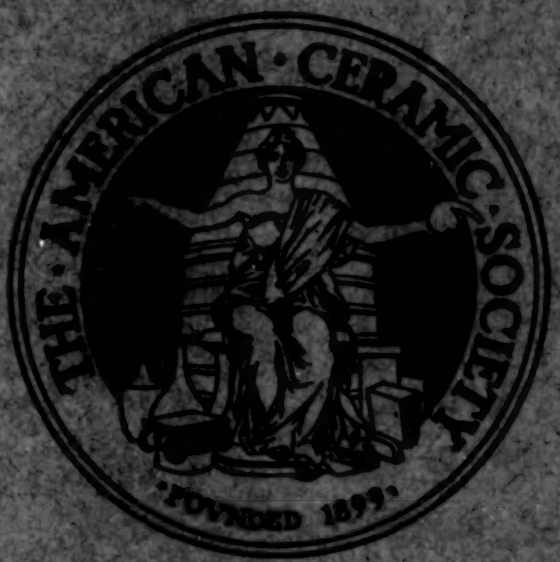

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ABSTRACTS
VOL. 13 NO. 10

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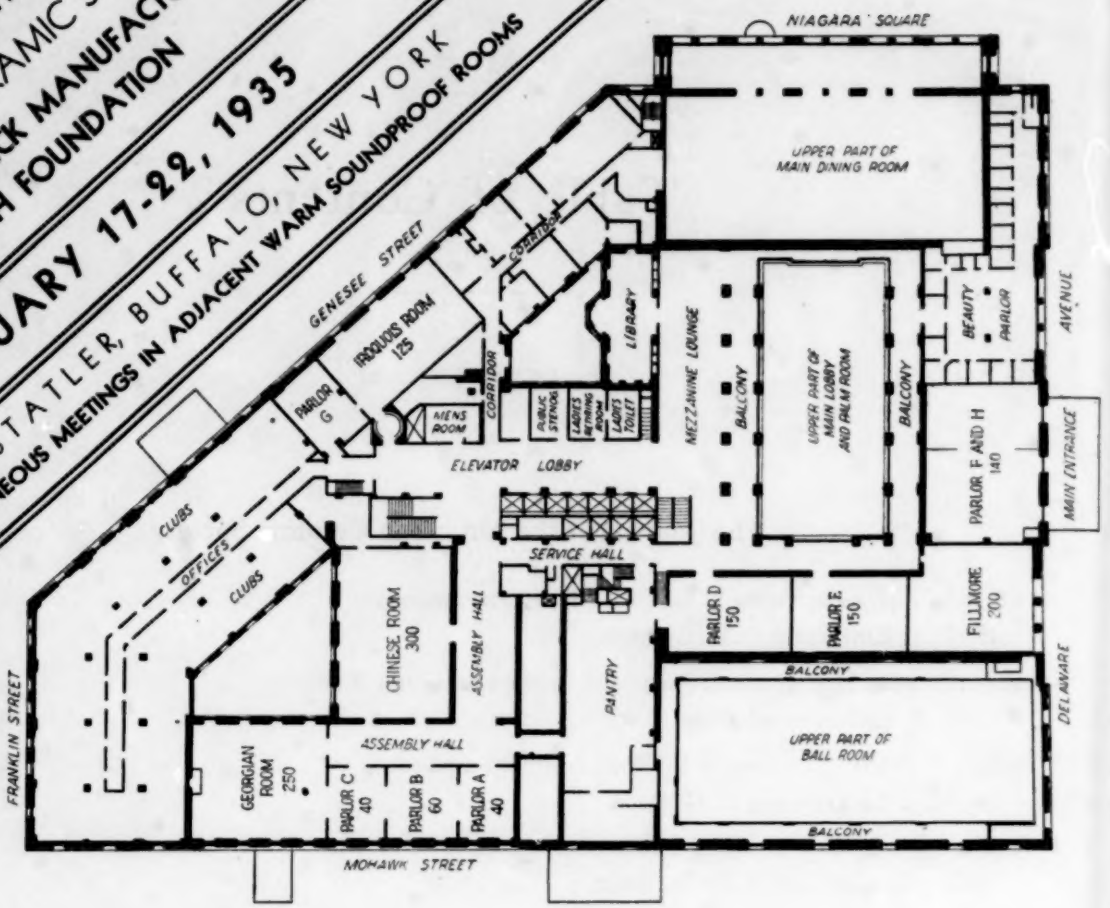
1935 ANNUAL MEETINGS

THE AMERICAN CERAMIC SOCIETY
THE NATIONAL BRICK MANUFACTURERS
RESEARCH FOUNDATION

FEBRUARY 17-22, 1935

HOTEL STATLER, BUFFALO, NEW YORK
EIGHT SIMULTANEOUS MEETINGS IN ADJACENT WARM SOUNDPROOF ROOMS



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THE EFFECT OF ZIRCONIUM OXIDE IN GLASSES, GLAZES, AND ENAMELS*

By C. J. Kinzie and C. H. Commons

ABSTRACT

The subject of zirconium opacity is discussed from the theoretical and practical standpoint.

I. Introduction

Zirconium oxide has been used successfully as an opacifying agent in enamels and glazes for some time, but its effect on the physical properties of the glass have only recently begun to be appreciated. For the purpose of this discussion its effects have been classified into two groups, (1) opacity and (2) other physical properties.

II. Opacity

Although the opacifying effect of zirconium oxide has been known for some time, it is only within the last decade that enough information has been obtained so that very densely opaque glasses could be consistently made which would take advantage of the properties of ZrO_2. The purpose of this discussion is to summarize the findings and conclusions which have been drawn from the work this laboratory has done to date, rather than to attempt to give formulas for the various conditions which might arise.

In general, opacity is due to a mixture of a crystalline phase dispersed in a glass and is dependent on the dispersion and refraction of the incident light being finally turned so as to come out of the surface again in the form of white light. Theoretically then, opacity should depend on three factors where transparent materials are used: (*a*) maintenance of two phases, (*b*) difference in refractive index of the two phases, and (*c*) fineness and dispersion of the one phase in the other. The fineness of a material can be regulated with fair accuracy. A limitation results from the fact that by nature transparent, colorless materials of high refractive index are not very insoluble in glass composition.

An examination of possible oxides or compounds which occur or can be made commercially available of sufficient purity to render them suitable for white pigments limits the use to such materials as antimony oxide, arsenic oxide, zinc oxide, zinc sulfide, tin oxide, titanium oxide, zirconium oxide, zirconium silicate, and possibilities of thorium oxides and silicates, if they can be produced at sufficiently low cost. With very low refractive indices there are gases, fluorides of sodium, calcium, aluminum, etc.

In considering the possibilities, zinc sulfide is eliminated because of the tendency to oxidize with the liberation of objectionable SO_2 or SO_3; arsenic, because of its poisonous nature; and zinc and titanium oxides, because of their high solubilities in the glass. Antimony oxide is good in certain applications, but its relatively high vapor pressure precludes its use at high temperatures. Tin oxide is a good opacifier, but has the objectionable property of being fairly easily altered by combination with chrome, for instance, to a pink or by reduction to a lower oxide, either of which defeats its purpose as a white pigment. Normally, it is rather expensive. Thorium compounds are relatively little known as ingredients for glasses and glazes.

Such materials of low index, as fluorides, have some value as opacifiers, but in this case the difference of the refractive index of the glass and the fluoride is much less than that obtained with a glass and a material of high refractive index, and, therefore, much less opacity will be produced from the same amount of the second phase in the glass. Experience has shown this to be the case because it has been found necessary to supply additional opacifiers in order to produce enough opacity to turn back sufficient light in a thin coating of glass.

(1) Zirconium Oxide Zirconium oxide has been used quite successfully in some cases, unsuccessfully in other cases. Its high refractive index should make it a good opacifier. The explanation of its failure as an opacifier probably lies in the fact that in certain types of compositions it is fairly soluble and goes into solution, thus eliminating one of the phases from the system.

In considering zirconium opacity, an examination is made of some of its properties. Zirconium metal has a great affinity for oxygen. At a temperature of about 300°C it will burn in air to ZrO_2. No other oxide of this metal is known. This oxide is stable at all temperatures encountered in ceramic glazing.

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (Enamel Division). Received February 14, 1934.

The first work in this laboratory was done on the formation of a ZrO_2 product which would replace tin oxide in enamels. Many processes were tried with varying results. Of the various products, relatively few were found to be satisfactory. Several of these products are now in use as opacifying agents, primarily as a mill addition to enamel frits and as a relatively small part of the ZrO_2 introduced in glazes. The major part of the zirconium-oxide content of the opaque glasses and glazes is introduced as a silicate which is less expensive. When in the proper combination, it will produce almost as much opacity as the ZrO_2 product. There still is some doubt as to whether the opacity thus produced is due to zirconium-oxide crystals or crystals of some other zirconium compound.

(2) Constituents Essential to Opacity with ZrO_2

Andrews and Breen[1] have stated that the X-ray did not indicate that zirconium-oxide crystals were present as such. At any rate, certain constituents either are necessary or very beneficial in producing zirconium opacity. One of these materials is Al_2O_3. This material is of primary importance, since a silicate low in Al_2O_3 will dissolve a large amount of ZrO_2 with little or no opacifying effect. Zinc oxide is of considerable importance, though apparently not of the same order as alumina. The following composition has no opacity without ZnO, but with 4% ZnO is fairly opaque.

Composition No. 1		Composition No. 1		
NaKO	20.00	0.6832 NaKO	0.2473 Al_2O_3	1.6896 SiO_2
ZnO	4.00	0.1375 ZnO		0.3188 ZrO_2
CaF_2	5.00	0.1793 CaO		0.1179 F_2
B_2O_3	12.00			0.4829 B_2O_3
Al_2O_3	9.00			
SiO_2	36.25			
ZrO_2	14.00			
	100.25			

However, certain other compositions being devoid of ZnO have very dense opacity. CaO and BaO in proper proportions will give practically the same opacity as ZnO. In order to show that the opacity thus produced is dependent on the ZrO_2 and not on a $ZnO–Al_2O_3$ or $CaO–BaO–Al_2O_3$ compound, the following composition was prepared, introducing the ZrO_2 as sodium-zirconium silicate. If one-half of the ZrO_2 content is replaced by Al_2O_3 in the form of feldspar, the opacity is only about 25% of the original. When all of the ZrO_2 content is replaced, there is only a faint milkiness to the glass.

Composition No. 2		Composition No. 2		
NaKO	8.41	0.37025 NaKO	0.36207 Al_2O_3	2.96929 SiO_2
CaO	5.00	0.30647 CaO		0.41932 ZrO_2
BaO	5.00	0.11206 BaO		
ZnO	5.00	0.21122 ZnO		
Al_2O_3	10.73			
SiO_2	51.90			
ZrO_2	15.00			
	101.04			

Generally, there is little that can be said which will apply to the whole range of temperatures for which various glasses are compounded. For instance, the following composition is very opaque at enameling temperatures, but when heated to temperatures above 1850°F, it begins to lose opacity by solution.

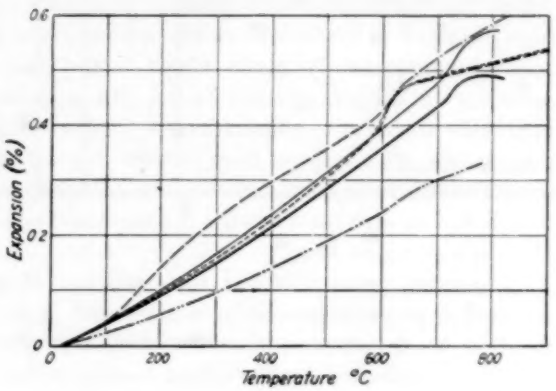

FIG. 1.

Composition No. 3		Composition No. 3		
NaKO	13.10	0.3939 NaKO	0.1829 Al_2O_3	1.0905 SiO_2
CaF_2	6.22	0.1931 CaO		0.2914 ZrO_2
Na_3AlF_6	3.96	0.4130 ZnO		0.2685 F_2
ZnO	13.87			0.4760 B_2O_3
B_2O_3	13.67			
SiO_2	27.04			
Al_2O_3	7.39			
ZrO_2	14.79			
	100.04			

Another composition which matures as a glaze at cone 3 (2093°F), but is almost a clear glass at cone 10 (2300°F), is as follows:

[1] A. I. Andrews and J. P. Breen, "X-Ray Investigation of the Opacifying Compounds Present in Sheet-Iron Cover Enamels," *Jour. Amer. Ceram. Soc.*, **16** [7], 325 (1933).

Composition No. 4		Composition No. 4		
NaKO	6.45	0.3130 NaKO	0.3160 Al_2O_3	3.3418 SiO_2
CaO	4.90	0.3308 CaO		0.4621 ZrO_2
BaO	5.00	0.1235 BaO		0.1088 B_2O_3
ZnO	5.00	0.2327 ZnO		
B_2O_3	2.00			
Al_2O_3	8.50			
SiO_2	53.00			
ZrO_2	15.00			
	99.85			

As compared with the above, compositions such as the following will mature at cone 1 and still be practically as opaque at cone 12 (2390°F).

Composition No. 5		Composition No. 5		
NaKO	7.78	0.3460 NaKO	0.2588 Al_2O_3	2.8440 SiO_2
CaO	5.29	0.3275 CaO		0.4236 ZrO_2
ZnO	5.00	0.2133 ZnO		0.2494 B_2O_3
BaO	5.00	0.1132 BaO		
B_2O_3	5.00			
Al_2O_3	7.59			
SiO_2	49.21			
ZrO_2	15.00			
	99.87			

Then, too, there are materials added to both enamels and glazes for the purpose of regulating the maturing temperature and coefficient of expansion which are not necessarily needed in glasses. There is considerable evidence that glasses can be made which are less complex in composition but probably of equal opacity. Because we have had meager facilities for testing the working properties of glass which would simulate plant practice, this work is incomplete and no composition has been found for which any characteristics can be given.

III. Zirconium in Glazes

Since more work has been done on zirconium opacity in the range of glazes, the following generalities have been drawn referring more specifically to this field, but which can be extrapolated to a considerable extent.

In this work, it has been found more advantageous to calculate compositions to the basis of percentage of the oxide content rather than to "norms" or "molecular formulas," as this method was found to be more adaptable to the prediction of results. No relationship of R_2O, RO, R_2O_3, etc., showing how to produce zirconium opacity, has been worked out. There is, however, an important relationship between individual members of each group. To date, the empirical relationship has not been determined.

NaKO The alkalis are primarily fluxes, but are used to some extent to control the expansion of the glass. They do not seem to exert any appreciable effect on the opacity when used in amounts up to 10% in glazes or up to 15% in enamels.

ZnO Although dense opacity has been produced with zinc-free glasses, it seems to be better to use this element where it is not objectionable, as it is somewhat easier to control for opacity and texture. It is easier to obtain a densely opaque yet glossy glaze with the use of zinc oxide. Although zinc-free glasses of dense opacity tend to be more mat in texture, good gloss glazes have been obtained without the use of zinc oxide but are generally more sensitive toward cooling conditions. This problem might not arise in the fields of enamels or glasses. The limits are not at all rigid, but about 5% seems to be sufficient for most glazes. Zinc is a fairly good flux of low expansion and can be used to vary the expansion of the glass.

CaO Calcium oxide is a constituent contributing somewhat toward the formation of zirconium opacity, but is desirable primarily as a flux and as a control of texture; usually 4 to 5% seems desirable.

BaO Barium oxide is an active flux contributing toward zirconium opacity. If too great an amount is used, it will precipitate in rather large crystals producing a texture varying from a mat to one which appears immature even though it is definitely known that the glaze was once melted to a good glass. About 5 to 7% seems to be an average amount of BaO for a good glaze.

B_2O_3 Boric oxide is slightly deleterious to the opacity, but this property is offset by its effectiveness as a flux and as an ingredient tending to produce a bright glossy glaze. Too much B_2O_3, of course, promotes crawling, but this tendency has been largely counteracted by adding 1% of CaF_2.

Al_2O_3 It has been found most advantageous to keep the Al_2O_3 content at about 10%. Less than 6.5% tends to reduce the effectiveness of ZrO_2 as an opacifier; more than about 14% makes a glaze which has too great a crystallization tendency.

SiO_2 Silica serves its usual function in a glaze and is varied to control hardness (maturing temperature) and texture, as well as

expansion. The control of expansion, however, has been found best regulated by other means. It should be kept as low as possible for zirconium opacity.

ZrO_2 In order to produce a densely opaque glaze which can be applied in thin layers with complete hiding power, it has been found best to incorporate about 15% ZrO_2 in the form of the relatively inexpensive pure zircon and the remaining 3, 4, 5, or 6% in the form of a ZrO_2 product.

It is noteworthy that pure white glazes were made with zirconium opacity in contact with chrome vapors under the same conditions that colored tin-oxide glazes various tints of pink. A pink with zirconium opaque glazes has never been produced by the use of chromium without the addition of tin or titanium oxide.

IV. Physical Properties Other Than Opacity

The first work along this line was prompted by our observation of certain zirconium opaque enamels that had good resistance to chippage, but when applied to thin-gaged steel and allowed to warp, bowed to a great extent. The same pieces when laid on a table would straighten out by their own weight to more nearly a flat surface than certain other specimens prepared in the same manner with enamels having much less original warpage. With this in mind, the crushing, tensile, and transverse strengths and modulus of rigidity of a variety of composition types were determined.

V. Method of Preparing Samples and Making Tests

The test specimens were cast from molten enamel frit by the following procedure:

Monel metal molds were made by machining a block of metal of such size that the finished mold had a minimum of $^1/_2$-inch wall. All molds were made in two pieces, split along the longest axis. The inner surface against which the enamel was to be cast was carefully smoothed with fine abrasive paper and buffed to give a fairly good polish. To prevent sticking of the glass to the mold, several materials were tried as a facing. The facing giving the best satisfaction consisted of hand-rubbing a thin coating of paste made by wetting powdered talc with light machine oil. This coating was found to prevent the glass sticking to the mold for a day's casting operation and was replenished before each day's run. The molds were held together with Monel metal "C" clamps. It was found necessary to lubricate these clamps with graphite or they would freeze so that they could not be opened.

Two electric muffle furnaces and two gas-fired smelters were used, the gas furnaces to smelt the enamels in crucible batches so that no part of the smelt was maintained in the molten state long enough to vary its heat treatment appreciably from that normally used in making the frit. The electric muffle furnaces were used as annealing furnaces according to the following method of procedure:

Iron boxes nearly filled with powdered Sil-O-Cel were put into the furnaces along with the molds and brought to a temperature which would permit easy working of the enamel glass without failure. At first this was a method of trial and error, but it was later found that the temperature best suited was one about three-fourths of the way from the critical annealing temperature to the softening temperature of the glass as shown by the interferometer curves.

By charging the smelters alternately, it was possible to maintain a cycle of casting which would work efficiently. This cycle was to remove the mold from the electric furnace and place it on a cold cast-iron slab $^1/_2$ inch thick for about 40 seconds, pour the molten glass into the mold and press it in with the Monel metal cover plate, then return the mold to the furnace as quickly as possible for a period of about 8 to 10 minutes. For most glasses 8 minutes were sufficient. The molds were then removed from the furnace with gloved hands and by pressing on the glass with the thumbs, it would usually drop out easily. The glass specimen was immediately put into one of the boxes of Sil-O-Cel. The mold was set on the iron rack and the cycle repeated. When the boxes of one furnace were filled, it was sealed up. After one-half hour the current was turned off and the furnace allowed to cool. By the next morning the boxes could be removed from the furnace and opened. With few exceptions, this method gave well-annealed pieces.

The inner dimensions of the mold for crushing strength were 1 inch in diameter by 1 inch high; for the transverse strength, the mold was rectangular, $^7/_8$ by $^7/_8$ by 6 inches long. The tensile strength piece was of a shape similar to that prescribed for refractories, cements, etc., and was $^1/_2$ inch thick, having a rectangular cross-section at the narrow point $^3/_4$ inch wide, the sides being

parallel for a length of $^1/_4$ inch before widening. The tests were made according to A.S.T.M. specifications.

Modulus of rigidity tests were made on strings having been formed while the rods were pulled apart vertically. With practice it was possible to draw strings practically circular in cross-section. Strings about 0.03 inch in diameter and about 25 to 30 inches long were used. The exact diameter was determined every inch of the length, and the average diameter was calculated. Only strings which were very nearly uniform were used. Three strings were used unless the results did not give check values, in which case more were used until check values were obtained. With careful selection of the specimens, the results usually checked fairly closely, but in some cases it was necessary to use a fourth string.

The materials necessary for the test are a supporting stand, a little sealing wax, and a flat uniform disk of metal whose moment of inertia can be readily obtained. A Monel metal disk, 6 inches in diameter and made of 16-gage stock, was used. A hole about 0.05 inch was bored in the center of the disk. One end of the thread was sealed into this hole with the sealing wax, and the other end sealed into a similar hole in the stand. By giving the disk a slight rotational impetus, the period for each string was determined. Knowing the moment of inertia of the disk and the length and cross-section of the thread, the modulus of rigidity of the glass thread was calculated. The threads were not annealed as our facilities did not permit this on this length of thread without bending some part of it. The results, however, are comparable since each enamel received the same treatment and good check figures could be obtained.

The results showed that composition No. 3 had a tensile strength of 4291 pounds per square inch; compressive strength of 16,879 pounds per square inch; modulus of rigidity of 1.743×10^{-11} dynes per square centimeter. Commercially good enamels, containing no zirconium oxide, varied from 2557 to 3724 pounds per square inch in tensile strength; 10,550 to 13,643 pounds per square inch in compressive strength; 2.373×10^{-11} to 2.794×10^{-11} dynes per square centimeter in modulus of rigidity. With certain compositions, the modulus of rigidity was brought down to 0.992×10^{-11} dynes per square centimeter with the introduction of ZrO_2. The determinations were all made on the enamel glass as melted without mill additions of clay or opacifier.

The results showed that not only were the compressive and tensile strengths increased greatly but, probably more important, the modulus of rigidity was lowered appreciably so that a certain definite stress resulted in less strain in the enamel glass. No significant differences in the transverse strength were noted for any enamels.

Such tests are difficult to apply to glaze compositions because of the difficulty of preparing specimen pieces due to the high temperatures at which the glass is fluid. However, a comparison of the interferometer-expansion curves of a glaze and the range of bodies it would "fit" without failure in three times in the autoclave test showed interesting and similar results.

VI. Conclusions

The general conclusions drawn from the preceding data are as follows:

(1) Zirconium oxide in proper combination imparts a high degree of opacity to a silicate glass.

(2) The amount of solution of zirconium oxide in glass is dependent to a large extent on the kind and amount of other constituents, such as aluminum oxide, zinc oxide, calcium oxide, barium oxide, etc.

(3) The zirconium oxide which goes into solution in the glass imparts properties to that glass which should be of distinct advantage. The tensile strength and compressive strength were increased and the modulus of rigidity decreased.

RESEARCH LABORATORIES
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THE EFFECT OF FLUORIDES ON THE PROPERTIES OF WHITE SHEET-IRON ENAMELS*

By A. I. Andrews and E. E. Howe

ABSTRACT

This investigation deals primarily with determinations of the thermal expansion and fusion properties of white sheet-iron cover enamels. A comparison of the results of the factor method of calculating the thermal expansions and those obtained experimentally shows considerable disagreement.

I. Method

The method of investigation is not new, the thermal expansion and fusion temperatures being determined by the use of the interferometer. The bending-thread method described by Andrews and Smith[1] was used for determining the annealing temperatures.

(1) Enamel Smelting The enamels were made in the usual laboratory manner, being smelted in crucibles, quenched in water, dried, and dry-ground to pass a No. 60 sieve. They were then milled with 6% clay, 40% water, and 5% tin oxide to a fineness of 18% residue on a No. 200 sieve. They were applied by spraying and fired in an electric furnace.

(2) Test Pieces The samples for interferometer and annealing tests were made by remelting about 50 grams of the dry frit which had been milled to pass a No. 60 sieve. They were held in a viscous state for one hour and then rods 0.5 to 5.0 millimeters in diameter were drawn from the melt.

For the annealing test, rods about 0.5 millimeter thick and 100 millimeters long were mounted on a porcelain base and placed in an electric furnace so that they projected in a horizontal direction. The temperature was then slowly raised over a definite heating schedule and the rods observed through the peep-hole in the door of the furnace. The softening temperature was taken as the temperature at which the rods showed pronounced deformation. Figure 1 shows the appearance of one of these tests.

(3) Interferometer Tests For the interferometer tests rods were annealed for fifteen minutes at the temperatures indicated by the annealing test and allowed to cool with the furnace. This eliminated the many strains resulting from rapid cooling.

Pieces of these rods about 5 millimeters in diameter and 5 millimeters long were then ground to a blunt point on one end and to a flat plane at the other. Three pieces were ground to the same height within 0.0002 centimeter as indicated by a micrometer caliper. They were then mounted in the interferometer furnace and adjusted until from four to six fringes appeared in the field of

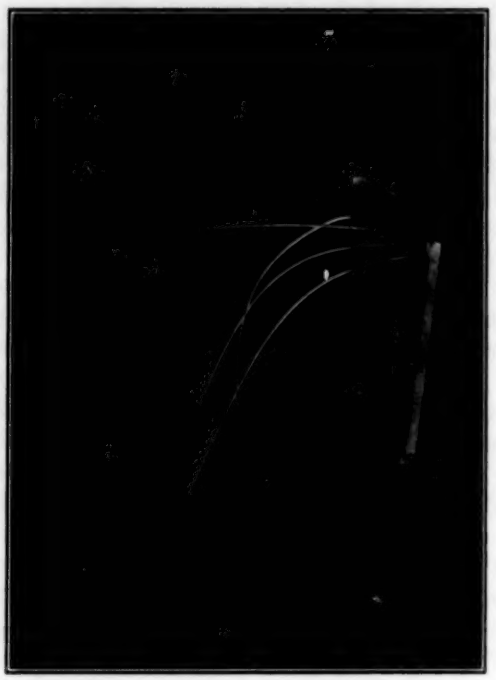

Fig. 1.

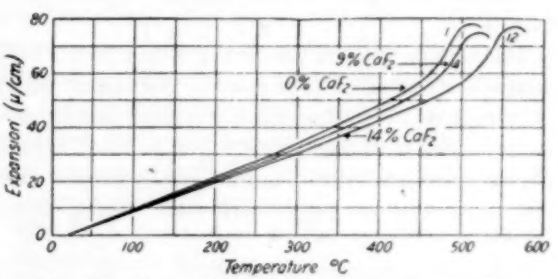

Fig. 2.—Effect of fluorspar on thermal expansion (enamels Nos. 1, 4, and 12).

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (Enamel Division). Received February 15, 1934.

[1] A. I. Andrews and R. K. Smith, *Jour. Amer. Ceram. Soc.*, **16** [7], 328 (1933).

view. As the temperature was raised over a definite heating schedule of 4°C per minute, the temperature at which every second fringe passed a reference point was noted. From these data, the expansions were calculated and plotted against

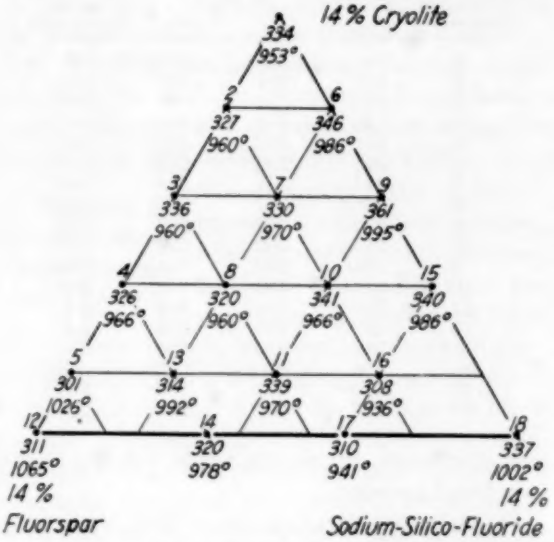

FIG. 3.—Softening temperatures in °F and expansion $\times 10^{-7}$ in the low-temperature range plotted against composition points.

Batch Composition			
Feldspar	30%	Soda ash	4%
Borax	26	Soda niter	3
Quartz	20	Sb_2O_4	3
			86%

temperature. Figure 2 shows some typical curves obtained in this manner. That point in the test at which the fringes started to move in the opposite direction was taken as the softening point and the temperature was recorded as the softening temperature. By dividing the linear thermal expansion by the corresponding temperature interval and multiplying the result by three, the cubical coefficient of expansion was obtained.

Check runs on different batches of the same enamel showed a variation of about 2%, which was within the limits of the accuracy of the method.

II. Results

Figure 2 shows the effect of fluorspar, when replacing cryolite, upon the observed thermal expansion of a white cover enamel.

The triaxial diagram, Fig. 3, shows the field of investigation, the observed cubical thermal expansion $\times 10^{-7}$ in the low-temperature range (20 to 100°C), and the softening temperatures.

The annealing and softening temperatures are given in Table I.

Table II is a compilation of the cubical thermal expansions and their corresponding temperature ranges.

TABLE I

ANNEALING AND SOFTENING TEMPERATURES

Enamel No.	Annealing Temp. (°F)	Softening Temp. (°F)
1	960	953
2	980	960
3	900	960
4	900	966
5	1040	1026
6	980	986
7	980	970
8	920	960
9	1000	995
10	960	966
11	1000	970
12	1020	1065
13	960	992
14	920	978
15	900	986
16	900	936
17	970	941
18	920	1002

TABLE II

OBSERVED COEFFICIENTS OF EXPANSION $\times 10^{-7}$ IN VARIOUS TEMPERATURE RANGES

Ename No.	Temp. (°C)	Coeff.	Temp. (°C)	Coeff.	Temp. (°C)	Coeff.	Temp. (°C)	Coeff.
1	18–102	334	100–350	382	350–475	735	20–475	445
2	13– 96	327	" "	375	" "	492	" "	405
3	15–102	336	" "	375	" "	504	" "	408
4	18–105	326	" "	366	" "	489	" "	398
5	14–119	301	" "	360	" "	372	" "	363
6	14– 97	346	" "	382	" "	366	" "	403
7	17–107	330	" "	361	" "	366	" "	390
8	17–100	320	" "	358	" "	470	" "	394
9	13–107	361	" "	394	" "	468	" "	413
10	14–102	341	" "	360	" "	432	" "	370
11	17– 98	339	" "	352	" "	439	" "	377
12	17–100	311	" "	337	" "	362	" "	341
13	14–100	314	" "	348	" "	448	" "	370
14	17–102	320	" "	343	" "	427	" "	359
15	16–100	340	" "	384	" "	482	" "	403
16	14–101	308	" "	384	" "	583	" "	399
17	13– 98	310	" "	353	" "	461	" "	375
18	17–100	337	" "	380	" "	461	" "	394

III. Discussion of Results

(1) Calculation of Expansion

Since the calculations of the theoretical expansions of the enamels were more consistent when the factors of Mayer and Havas[2] were used, they were adopted for the present discussion. As there are several different ways in which the materials may go into solution, all different methods were calculated. These results and also the actual observed values for the low-temperature range are shown in Table III and Fig. 4. At the bottom of the figure the amounts of each variable present in the individual enamels are shown.

In this figure the points marked "logical fluorides" were determined by calculating the batch compositions to the melted compositions on

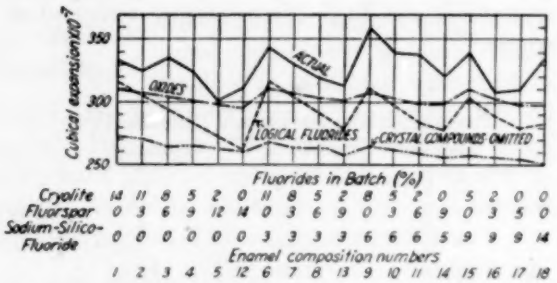
Cubical expansion X10⁷
350
300
250
ACTUAL
OXIDES
LOGICAL FLUORIDES
CRYSTAL COMPOUNDS OMITTED
Fluorides in Batch (%)
Cryolite 14 11 8 5 2 0 11 8 5 2 8 5 2 0 5 2 0 0
Fluorspar 0 3 6 9 12 14 0 3 6 9 0 3 6 9 0 3 5 0
Sodium-Silico-Fluoride 0 0 0 0 0 0 3 3 3 3 6 6 6 5 9 9 9 14
Enamel composition numbers
1 2 3 4 5 12 6 7 8 13 9 10 11 14 15 16 17 18

FIG. 4.—Comparative values of thermal expansion of fluoride enamels.

the basis of 100%. Cryolite was assumed to be broken down on entering the melt, contributing sodium fluoride, aluminum oxide, and fluorine gas. Sodium-silico-fluoride was assumed to be broken down into sodium fluoride, silica, and fluorine gas. All other raw materials were considered as the simple oxides. Each oxide or fluoride was multiplied by its expansion factor, and the sum of these quotients gave the theoretical cubical coefficients of thermal expansion.

The results marked "oxides" were obtained by assuming that the fluorine was completely volatilized and by calculating the remaining elements as oxides.

Assuming that the compounds, sodium fluoride, calcium fluoride, and antimony pentoxide, do not affect the expansion of the glass, they were subtracted from the composition, the remaining glass was calculated to 100%, and the factors were applied. These results are labeled "crystal compounds omitted." Although this assumption has often been made in the calculations of the expansion of enamels, the results would indicate that it is not well founded.

TABLE III

CALCULATED AND ACTUAL VALUES OF THERMAL EXPANSION OF FLUORIDE ENAMELS

Composition No.	Actual	Oxides	Logical fluorides	Crystal compounds omitted
1	334	310	316	272
2	327	307	305	270
3	336	304	293	264
4	326	302	284	266
5	301	298	272	262
12	311	294	262	260
6	346	311	318	268
7	330	307	304	263
8	320	303	292	262
13	314	302	279	256
9	361	308	311	264
10	341	303	298	262
11	339	298	284	258
14	320	299	278	255
15	340	310	304	257
16	308	300	289	256
17	310	297	280	254
18	337	297	283	250

Several other variations from these three types of calculations were made, but the variation was slight and the results are not shown.

Figure 4 shows that all calculated coefficients of expansion of the enamels containing fluorides were low compared to those actually observed.

Although the average of the oxide values for the different enamels is closer to the actual values, those obtained by calculating the logical fluorides more closely parallel the actual values and, although low, are therefore more indicative of the variation from one enamel to another.

Since the logical fluoride values parallel fairly closely the observed values, expansion factors for sodium fluoride and calcium fluoride were calculated which for the enamels studied would indicate the actual values. These new factors, calculated from enamels Nos. 6 and 7, were CaF_2 4.1 and NaF 10.0. These factors are not proposed to replace those of Mayer and Havas as they are based on only a limited amount of data. Only the values for calcium fluoride and sodium fluoride were raised since Mayer and Havas factors have been shown to check quite closely in ground-coat enamels with smaller percentages of fluorine compounds. It should be further understood that, although these values are applied to fluorides, the actual cause for the increased expansion may be due to the effect of the fluorides on the properties of the other materials.

[2] M. Mayer and B. Havas, *Sprechsaal*, **42**, 497 (1909); **44**, 188, 207, 220 (1911).

(2) Increase of Sodium-Silico-Fluoride Increases Expansion

Further examination of Fig. 4 shows that the trend of increasing expansion is in the direction of increasing sodium-silico-fluoride (see points 1, 6, and 9). This is contrary to the expected results. One possible explanation of this is that the sodium-silico-fluoride, being relatively unstable, is more completely broken down, thus giving a greater amount of sodium fluoride than that obtained from cryolite.

(3) Increase of Fluorspar Decreases Expansion

There is very little difference between individual enamels since actual values lie between 300 and 360 centimeters per centimeter per degree times 10^{-7}. Nevertheless, the trend of decreasing expansion with increasing fluorspar may be noted when replacing either cryolite or sodium-silico-fluoride. In the case of cryolite replacing sodium-silico-fluoride, the expansion tends to reach a maximum at a point about midway between the two and then decreases on either side of this concentration. The fact that fluorspar decreases the expansion might be expected since it is apparent that an addition of either cryolite or sodium-silico-fluoride means an addition of soda with a factor of 10.0 while the factor for lime is 5.0.

(4) Annealing Temperatures

The annealing temperatures as determined by the bending-thread method were quite satisfactory as evidenced by the expansion curves. If the samples had not been annealed, a lag in the expansion curve at from 50 to 100°C below the softening point would result.

The annealing temperatures do not parallel the softening temperatures in all cases. This may be attributed to viscosity which is secondary in the interferometer fusion test. A good example of this was noted in the values for enamel No. 18 (14% sodium-silico-fluoride). This enamel was quite fluid when smelted even at a low temperature indicating a low viscosity. The annealing test indicated a temperature of 920°F, but the softening temperature as determined by the interferometer was 1002°F. All of the enamels with a high soda content were more fluid than those containing high lime, indicating that soda lowers the viscosity.

IV. Summary

(1) In the range of enamel compositions studied in this investigation, none of the published factors was applicable. Those of Mayer and Havas, however, were most satisfactory and were therefore used in the calculations.

(2) The expansions of different enamels calculated as logical fluorides, although low in all cases, varied with the actual values.

(3) Two new factors for use in white sheet-iron cover enamels of the type used in this investigation were calculated as CaF_2 4.1 and NaF 10.0.

(4) Fluorspar, substituted for cryolite or sodium-silico-fluoride, decreased the coefficient of thermal expansion.

(5) The bending-thread method was shown to be a convenient test for determining the annealing temperatures.

(6) The annealing temperature was not always indicative of the softening temperature.

(7) Fluorspar did not affect the softening temperature to a very great extent when used in concentrations of less than 9%.

(8) Sodium-silico-fluoride, substituted for cryolite alone, tended to increase the softening temperature.

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EFFECT OF WATER HARDNESS ON VITREOUS ENAMEL SUSPENSIONS*

By A. I. Andrews and E. G. Porst

ABSTRACT

A study of the effect of natural waters of varying hardness on the yield values and mobilities of enamel slips using the Gardner mobilometer is given.

I. Introduction

Porcelain enamel manufacturers sometimes experience difficulty in the application of ground-coat enamels. A ground coat or combination of ground coats with a specific mill formula may work satisfactorily in one plant, whereas this same combination may prove entirely wrong in another plant one or two hundred miles distant. Of the aforementioned difficulties that are experienced are the so-called copperheads which may be prevalent in the one case and not in the other. Fishscaling sometimes occurs in a like manner.

Although the enamels may be handled identically, with uniform and good shop practices, clay and other raw materials obtained from the same source, in fact with everything in the two plants as nearly alike as possible, a wide difference in results is sometimes obtained.

Until recently, the water used in making up the mill batch had never been suspected. There is a possibility, however, that the evils already mentioned may, in part, be caused by a difference in hardness of the water, if one may judge by a number of instances where a change from natural to distilled water has cleared up these troubles.

Hardness of water probably affects the draining time. For instance, it is desirable to have a certain amount of borax in the mill to effect minimum draining time, but in certain localities, with this percentage of borax, it is necessary to add so much water to obtain the proper weight per square foot of ware that the liquid enamel becomes difficult to work. There are such narrow limits between the amount of water that it is necessary to add and the amount which makes the enamel not usable, that it is easy to spoil a dipping tank full of enamel.

The trouble which results from adding too much water is called "watermarking," "water runs," or "water streaks." Excessive amounts of water resulting in early loss of "set" cause "orange peel" and double draining. Ware affected in this manner must be washed off and redipped. This trouble occurs in some localities to a greater degree than in others. It can be corrected to a certain extent by the addition of soda.

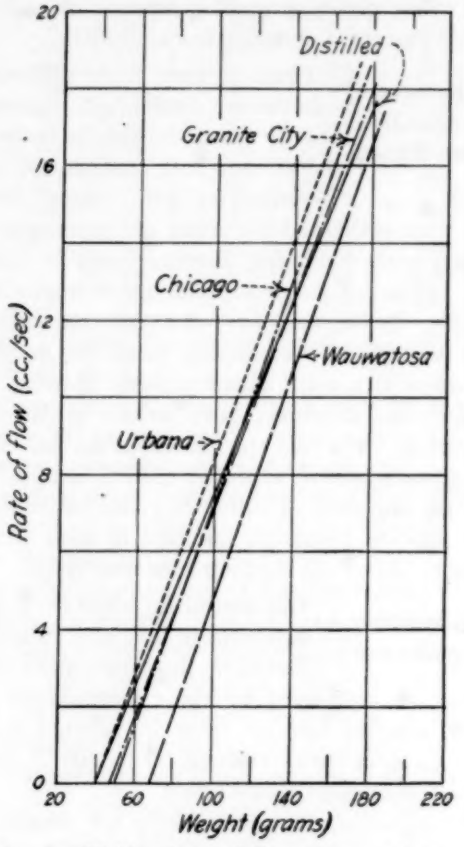

Fig. 1.—Yield value mobility curves: electrolyte 0.4% borax, water 60%.

Mill No.	Yield value (g.)	Mobility	Water
8a	40	2.50	Distilled
8a	40	2.84	Urbana
8a	48	2.77	Granite City
8a	50	3.00	Chicago
8a	68	2.90	Wauwatosa

In defining the consistency of a slip, two physical properties may be used: (1) "mobility," a measure of the rate at which the slip drains off before setting and (2) "yield-value," which determines the amount of enamel that remains on setting. In this investigation the effects of various hard waters upon the yield and mobility values of enamel slips were studied.

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (Enamel Division). Received February 21, 1934.

II. Plan of Investigation

The plan of this investigation may be divided into three separate fields as follows:

(1) The effect of different hardnesses of water on the mobility and yield values of enamel slips containing no electrolyte additions.

(2) The effect of different hardnesses of water on the mobility and yield values of enamel slips containing various percentages of sodium carbonate.

(3) The effect of different hardnesses of water on the mobility and yield values of enamel slips containing various percentages of borax.

III. Materials and Apparatus

(1) Enamel The ground-coat enamel used throughout the tests corresponded to the following formula:

Feldspar	30.0% by weight	Soda niter	4.0
Borax	31.0	Fluorspar	6.0
Quartz	20.0	Cobalt oxide	0.5
Soda ash	7.0	Manganese oxide	1.5
			100.0%

The raw batch of 120 pounds, owing to the size of the rotary smelter, was smelted in two portions. The frit was ground dry to pass a No. 20 sieve and afterward thoroughly mixed by rolling it on canvas, thus insuring a homogeneous mass.

(2) Clay The clay used was of the German "Valendar" imported grade. This material was stored in an air-tight container to prevent changes in moisture content during the tests.

(3) Mills The mills were $6^3/_4$ inches inside diameter by 7 inches in depth. The balls were equal in number in each case and of the same weight. This precaution was observed in an effort to obtain reproducible results with the several mills grinding under like conditions.

(4) Mill Additions The following mill additions were used in each test and were kept constant:

Frit (dry)	800 grams
Clay (Valendar)	48 grams

In these additions, different hardnesses of water and kinds and amounts of electrolytes were made the variables (see Section IV). The waters were of the following degrees of hardness: (*a*) Distilled water, zero hardness; (*b*) Chicago lake water, low hardness; (*c*) Granite City water (St. Louis), medium hard; (*d*) Urbana well water, hard; and (*e*) Wauwatosa water (Wis.), very hard.

(5) Consistency Apparatus A Gardner mobilometer[1] was used throughout this investigation to determine the yield and mobility values of the various enamel slips.

IV. Experimental Detail

(A) Analysis of Waters

The waters were analyzed as follows:

(1) Total Hardness, Soap Method A standard $CaCl_2$ solution was prepared by digesting 0.2 gram of chemically pure $CaCO_3$ in dilute HCl, evaporating several times to dryness with distilled water, and finally making up the solution to one liter in a volumetric flask.

For the standard soap solution, 100 grams of dry white castile soap were dissolved in 1 liter of 80% ethyl alcohol until exactly 6.4 cubic centimeters of it yielded a permanent lather when added to exactly 20 cubic centimeters of the standard $CaCl_2$ solution.

To determine the hardness of the waters, 50 cubic centimeters were measured into a glass-stoppered bottle, and the standard soap solution added dropwise, shaking at intervals of 0.5 cubic centimeter until a permanent lather persisted for five minutes. The number of cubic centimeters of soap solution were referred to a hardness table[2] to obtain the hardness of the water.

(2) Chlorine A standard NaCl solution was prepared by dissolving 16.5 grams of fused chemically pure NaCl in distilled water and diluting to one liter in a volumetric flask. Exactly 100 cubic centimeters of this solution were further diluted with distilled water to 1 liter (1 cc. standard solution = 0.001 g. Cl).

Then 2.396 grams of chemically pure $AgNO_3$ were dissolved in one liter of distilled water (1 cc. = 0.0006 g. Cl).

A saturated solution of K_2CrO_4 was used as indicator.

To determine the Cl content of the water, 50 to 100 cubic centimeters were measured into a white porcelain dish and three drops of K_2CrO_4 indi-

[1] G. H. McIntyre and J. T. Irwin, "Application of the Gardner Mobilometer to Enamel Slip Consistency Studies and Controls," *Jour. Amer. Ceram. Soc.*, **15** [8], 433 (1932).

[2] Griffin, Technical Methods of Analysis.

cator added. The standard $AgNO_3$ solution was added dropwise until a faint orange precipitate formed. The intensity of this color was matched with that of the standard NaCl titration (number of cubic centimeters of $AgNO_3 \times 0.0005$ = grams Cl present).

(3) Total Alkalinity Total alkalinity was determined by titrating 100 cubic centimeters of the sample water with 0.02 $N H_2SO_4$ solution in the presence of methyl orange indicator to a slight pink color (number of cubic centimeters of $H_2SO_4 \times 10$ = equivalent parts $CaCO_3$ per million parts water).

(4) Calcium and Magnesium Carbonates These constituents were determined on the same sample. For calcium carbonate, 100 grams of the water were acidified with HCl and evaporated to dryness on the sand bath. The dried salts were leached out in 10 cubic centimeters of concentrated HCl plus 50 cubic centimeters of distilled water, and the solution was filtered and made up to 150 cubic centimeters with water. Concentrated NH_4OH was then added until the solution showed just neutral to methyl orange, and heated to boiling. Fifty cubic centimeters of a saturated $(NH_4)_2C_2O_4$ solution were added with constant stirring and the precipitate was permitted to stand overnight.

The calcium oxalate was filtered off (reserving the filtrate for $MgCO_3$ determination), washed five times with hot water, and dissolved in 100 cubic centimeters of 5% hot sulfuric acid. The solution was titrated, while hot, with 0.05 N-$KMnO_4$ to the first signs of a faint pink color (number of cubic centimeters of $KMnO_4 \times 0.00248$ = grams $CaCO_3$).

(5) Magnesium Carbonate The filtrate from the calcium oxalate precipitation was evaporated to a volume of approximately 100 cubic centimeters, cooled, and 25 cubic centimeters of a 10% solution of $NaNH_4HPO_4$ added slowly, stirring vigorously at the same time. The magnesium ammonium acid phosphate, after standing overnight, was filtered, washed ten times with a 10% NH_4OH solution, and ignited to constant weight in a porcelain crucible (grams of $Mg_2P_2O_7 \times 0.7573$ = grams of $MgCO_3$).

(6) Sulfates Sulfates were determined by the usual barium chloride method. One thousand grams of the sample water were evaporated to approximately 100 cubic centimeters, being previously acidified with dilute HCl. The solution was then filtered, the filter paper washed with hot water, and the filtrate heated to boiling. Stirring the mixture continuously, 20 cubic centimeters of a 10% $BaCl_2$ solution were slowly added and the precipitate left to stand overnight. The $BaSO_4$ was filtered on a fine textured filter paper, washed five times with a hot 2% HCl wash, and finally ignited to constant weight in a porcelain crucible ($BaSO_4 \times 0.4115$ = grams SO_4).

For detailed and more complete information on these methods of analysis the reader is referred to standard textbooks[3] on the subject.

ANALYSIS OF WATERS

	Chicago	Granite City	Urbana	Wau-watosa
Total alkalinity	100	147	308	
Chlorine (p.p.m.)	5.6	14.0	7.7	11.2
$CaCO_3$ (p.p.m.)	81.9	126.5	154.8	
$MgCO_3$ (p.p.m.)	39.3	66.0	89.3	
$CaCO_3$ equivalent to $MgCO_3$	46.6	78.3	106.0	
Sulfates (p.p.m.)	9.5	55.5	4.7	
Hardness (soap titration)	137.2	207	266	400.0
Hardness (gravimetric method)	128.5	204.8	260.8	

The above waters were stored in 10-gallon glass carboys which were fitted with glass tube siphons. In this way water could be drawn off when needed; at the same time the supply was not exposed to the atmosphere, and consequently decomposition of the salts contained in the water was reduced to a minimum.

(B) Milling Practice

It is obvious that in an investigation of this kind it is necessary to control temperature and keep it constant. For this reason all waters, enamel, raw materials, and apparatus connected with the operations, were set up in the same room. The temperature of this room was approximately 23°C and did not vary more than ± 1.5°C throughout the tests.

Ball mills were thoroughly saturated with water overnight before each run to prevent unequal absorption of water which would result were the porosities of the individual mills widely different from one another.

All mill additions, including electrolytes, were added at the beginning of each run.

The rotating apparatus was equipped with a counter, so that each sample could be milled the

[3] Hillebrand and Lundell, Applied Inorganic Analysis.

same number of revolutions, 10,000. The motor used for power was constant in speed (during all the tests the total time of milling, three hours, did not in any case vary more than 5 minutes from this value). Thus the revolutions per minute were fairly constant, which is important from the standpoint of keeping all factors, other than the variable, constant throughout the tests.

V. Enamel Slips Minus Electrolyte

(1) Results Results of these tests are to be found tabulated under Table I. It will be noted that two tests were determined for each mill to afford check results.

(2) Summary From the results obtained it is impossible to draw any conclusions regarding the effect of the water hardness on the milled enamel slip. Not only were the mobility and yield-value checks between mills worthless, but the checks on the same mill failed to agree. From the standpoint of specific gravity the slips, as the values indicate, were identical. The screen tests likewise bear out uniform grinding conditions.

It is possible that the erratic results obtained were caused by the very poor set of enamels, since no electrolyte was used in these tests. This instability was apparent even during the brief time of test, a thick layer of coarse enamel particles having remained in the mobilometer cylinder after the liquid had been removed.

Since the reproducibility of the mills showed up so poorly, it was decided to abandon this phase of the investigation.

TABLE I

Electrolyte, none; water, 40% (Urbana)

Mill No.	Yield	Mobility	On 200-mesh (200 g. sample)	Specific gravity
8a	12	0.95	7.1 g.	1.79
8b	28	1.24	8.8	1.78
31a	0	1.00	8.7	1.79
31b	24	1.18	9.8	1.79
47a	17	1.00	8.5	1.79
47b	30	1.37	7.6	1.78
56a	6	1.07	9.1	1.79
56b	20	1.22	9.7	1.79

VI. Sodium Carbonate Group

(1) Results Yield and mobility curves for this group are not shown but the values are to be found assembled under Table II.

The working properties of this group of slips were not greatly different from those of Group V, containing no electrolyte. The formation of the coarse particle layer at the bottom of the mobilometer cylinder was likewise evidenced.

(2) Summary Owing to the instability of these enamel slips during tests, no conclusions can be drawn as to the effects of water hardness on enamel slips containing sodium carbonate electrolyte.

From the results on yield values and mobility values under the conditions of the tests imposed, sodium carbonate may be said to increase these factors slightly.

TABLE II

Electrolyte, 0.5%; sodium carbonate; water, 40%

Mill No.	Distilled water Mob.	Yield	Chicago water Mob.	Yield	Granite City water Mob.	Yield	Urbana water Mob.	Yield
47a	1.51	42	1.60	36	1.43	30	1.30	30
47b	1.31	37	1.35	28			1.20	30
47c			1.32	28			1.40	40
47d							1.47	48

VII. Borax Group

(1) Results of 0.3 Borax The results of 0.3% borax as electrolyte are shown on Figs. 2 and 3. Wauwatosa water, the hardest of the group, produced the greatest yield and mobility values, whereas distilled water produced the least. The remaining waters, whose hardnesses (see Analysis of Water) are intermediate between those mentioned before, effected results which were intermediate between the two extremes.

Using 0.3% borax as electrolyte, the effect of increasing hardness of water is to increase the yield and mobility values of the enamel slips. One exception to the above is that of the Urbana water slip which showed a lower yield value than those of the softer waters, Granite City and Chicago.

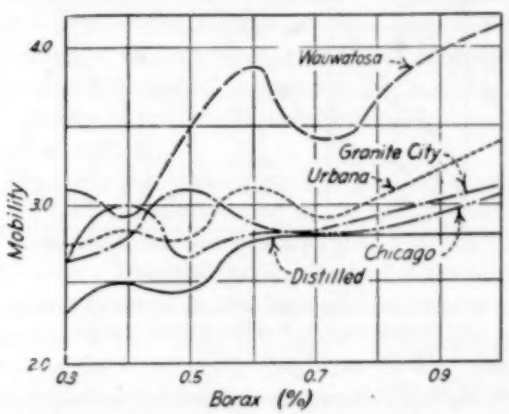

FIG. 2.—Effect of additions of borax on the mobility of enamel slips with different mill waters.

(2) Results of 0.4 Borax In this group Wauwatosa water produced the greatest yield value (see Fig. 1), and Urbana and distilled waters the lowest yield, the latter two being identical. Chicago water showed the greatest mobility value of the group. The remaining waters have intermediate values as shown.

With 0.4% borax as electrolyte, an increased hardness of water produces an increased yield value for the enamel slip. An increase in hardness of water increases mobility in a somewhat erratic manner.

(3) Results of 0.5 Borax From Figs. 2 and 3, it is shown that Wauwatosa water produced the greatest yield and mobility values and distilled water the least. These values varied according to the hardness values of the waters.

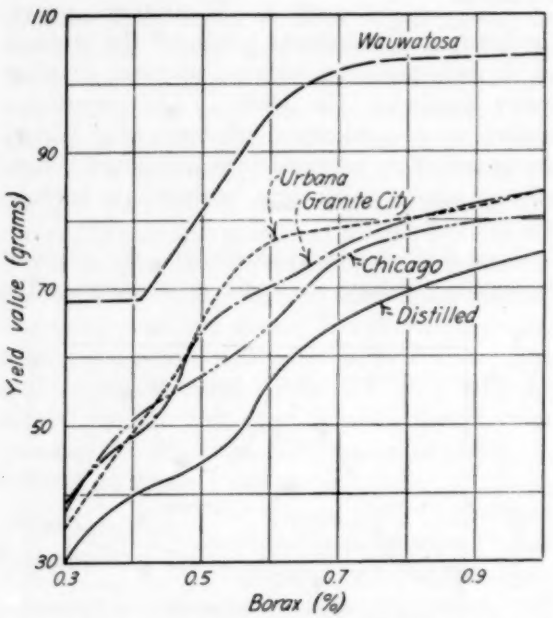

FIG. 3.—Effect of additions of borax on the yield value of enamel slips with different mill waters.

With 0.5% borax as electrolyte, mobility and yield values of the enamel slip vary directly as the water hardness.

(4) Results of 0.6 Borax An inspection of the data on Figs. 2 and 3 shows that distilled water produced the smallest mobility and yield values. Increasing the hardness of water correspondingly increased the yield and mobility values. The maximum values were obtained using Wauwatosa water, the hardest water of the group.

Using 0.6% borax as an electrolyte, yield and mobility values increase progressively as the hardness of the water is increased.

(5) Results of 0.7 Borax The results and conclusions of these tests are analogous to those of the 0.6% borax group (see Figs. 2 and 3).

(6) Results of 1.0 Borax These results and conclusions are likewise in accord with those of tests with 0.6 and 0.7% borax (see Figs. 2 and 3).

TABLE III

Borax (%)	Mill No.	Distilled water Mob.	Distilled water Yield	Chicago water Mob.	Chicago water Yield	Granite City water Mob.	Granite City water Yield	Urbana water Mob.	Urbana water Yield	Wauwatosa water Mob.	Wauwatosa water Yield
0.3	47a	2.66	34	2.51	36	2.64	38	2.72	34	3.09	68
0.3	47b	2.17	22								
0.3	47c	2.39	30								
0.4	8a	2.50	40	3.00	50	2.77	48	2.84	40	2.09	68
0.5	8a	2.44	44	2.55	58	3.09	64	2.77	64	3.36	81
0.5	8b			2.80	60						
0.6	8a	2.67	56	2.81	65	2.87	70	3.12	77	3.88	96
0.7	56a	2.79	65	2.79	74	2.83	76	2.89	78	3.40	102
1.0	56a	2.79	75	3.18	81	3.12	84	3.40	84	4.12	104
1.0	56b			2.82	81						
1.0	56c			3.10	80						

VIII. Summary of Results and Conclusions

Results obtained using no electrolyte in the one case and sodium carbonate in the other, did not check among themselves. Enamel slips milled under these conditions exhibited such poor "set" as to be classed as worthless. Good check results on screen tests and specific gravities were obtained on the above slips.

The effects of hardness of mill water on enamel slips containing various percentages of borax as electrolyte may be seen in Figs. 2 and 3. An inspection of these curves proves unquestionably that a hard water increases the mobility and yield values of an enamel over what these values would be were a softer water used.

It is also of interest that maximum rate of increase in yield values occurs approximately within the limits 0.4 to 0.7% borax. Below or above these two extremes, the changes in yield values are less marked for equal units of borax.

The mobility *versus* borax curves are singular in that each approximates a sinuous form. In other words, when borax is added in small quantities at a time to an enamel slip, the mobility will reach a maximum at a certain given quantity, then drop below this amount on further additions, and again

reach a higher peak than the previous one with more borax, and so on. In the enamel-slip consistency studies of McIntyre and Irwin,[4] these authors obtained results similar in nature, although their work did not mention them. Harrison,[5] in his exhaustive work using the consistometer, stated that electrolytes such as borax, magnesium carbonate, and others, had very little effect on the mobility. This, indeed, seems contrary to the results obtained in this investigation. It may be that the consistometer, as an instrument for measuring mobility, is less sensitive to changes than the Gardner mobilometer.

These erratic effects of borax on mobility are also borne out by previous workers in other fields. Taylor[6] found a like phenomenon in his study on the effect of zinc-sulfate concentration on coagulation of albumin and the coagulation of gels in water by increased concentrations of sodium chloride, potassium chloride, and sodium nitrate. Salts which he found to be exceptions to this rule were sodium sulfate and ammonium sulfate. Again, Kruyt[7] experienced the same results in his study of sols to which he ascribes the name "irregular series."

NOTE: The authors believe that this work and the conclusions have merely scratched the surface of what appears to be a very complex problem. The theory of colloidal chemistry (for we are, among other things, dealing with colloids in the enameling industry) is still in its infancy, which renders the problem even more inscrutable. It is to be hoped, however, that the facts presented in this investigation may stimulate further work along these lines, so that eventually some of the many difficulties existent in the modern enameling industry may be brought under control.

[4] G. H. McIntyre and J. T. Irwin, *loc. cit.*
[5] W. N. Harrison, "Vitreous Enamel Slips and Their Control," *Jour. Amer. Ceram. Soc.*, **10** [12], 970–94 (1927).
[6] W. W. Taylor, The Chemistry of Colloids, p. 120.
[7] H. R. Kruyt, Colloids, p. 86.

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EFFECT OF DELAY IN ENAMELING PICKLED SHEET IRON*

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ABSTRACT

The effect of delay in enameling pickled sheet iron is shown as promoting copperheads in the ground coat. This is especially true of the old type of viscous single-glass ground coat. The modern two-glass ground coat was not affected by the pickling procedure.

I. Introduction

Adsorption of acid on the surface of sheet steel during the descaling process at the sheet mill has been suspected as one of the causes of copperheading during ground-coat application. The enameler has never taken the trouble to check up on this phase of the copperheading problem, preferring rather to modify his enamel formulas to overcome the difficulty. He has been long suffering and meek, many times taking the blame for culls which were not of his making. He simply studied his raw materials to learn their peculiarities, until today he has a fair knowledge of how combinations of raw materials modify or annul defects in the ware.

As stated above, the enameler has long suspected the adsorption of acid at the sheet mill as being one cause for copperheading of the ground coat. The enameler was not the only person suspicious. In fact, one of the steel companies has installed special equipment to remove as completely as possible this residual acid from the pickling process.

The descaling of sheet steel or pickling process which follows the annealing at the mill is effected by immersing the steel in a dilute, hot sulfuric-acid bath. The steel is then washed, after which the "carry over" or residual acid is supposedly neutralized in a suitable alkaline bath. We say "supposedly" advisedly because if the wash, which is usually hot water, removes any of the acid it should remove all and no neutralizing bath would be necessary. It is deduced then that if the hot-water wash does not remove the acid, the alkaline bath will not complete the job. The theory which led to this investigation is briefly explained. It is well known that with etched, hence porous surfaces, surface tension and capillary action give rise to powerful forces which

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tend to occlude tenaciously such suitable liquids as may come in contact with these surfaces. The question, then, naturally arises as to whether or not the "carry over" or occluded pickling acid could be completely neutralized by the alkaline wash. If complete neutralization takes place all is well; if not, then the products of the reaction between occluded acid and steel may give rise to serious trouble such as copperheading during the enameling process, especially if the lapse of time between sheet-mill pickling and enamel-plant pickling is of any duration.

This work was conducted in an effort to determine the extent of copperheading as affected or effected by (1) occlusion of cleaner; (2) occlusion of acid pickle; (3) kind of acid pickle, *i.e.*, sulfuric and hydrochloric acids; (4) kind of neutralizer (*a*) soda, (*b*) soda followed by borax, and (*c*) soda borax mixture; (5) age of steel after sheet-mill pickling or, in other words, simulating the length of time-lapse between sheet-mill pickling and enamel-shop pickling; (6) freshly milled ground coat *versus* aged ground coat; and (7) viscous or old-type single-frit ground coat as compared with the fluid present day two-frit combination.

II. Procedure

There is a period of time which lapses between the pickling of the enameling metal at the sheet mill and the pickling and enameling of the same metal in the enameling shop. In order to simulate this condition one-half of the specimens used were pickled and then allowed to age six weeks before repickling and enameling.

An inspection of the tabulated results will indicate the various steps followed systematically in obtaining the data in this investigation. Since the work had to be carried on with steel already pickled at the mill, there may have been some occluded acid already in the pores, which may account for a few apparent discrepancies in the results. The periods of time of milling and pickling were so correlated as to permit the same millings of enamels, both viscous and fluid, to be used throughout the work. In this manner variations were eliminated which would have resulted were two or more batches of enamel milled at different times.

It should be explained here that all specimens were repickled just before enameling in order to duplicate regular plant practice

III. Materials Used

Two types of ground-coat enamels were used in this work. The first was the single-frit type which was in popular use by the trade until a few years ago. It produces excellent ware but is viscous and will develop copperheads when the quality of the steel is questionable. It is still used by many enamelers because of its ability to withstand mechanical shock and its freedom from other defects. The second type of ground coat was the two-frit type developed principally to overcome copperheading tendency. Such consists of a hard and a soft glass usually mixed in the mill during grinding in the proportion of 70% hard glass and 30% soft glass. These two types of ground coats were chosen because first, the single-frit ground would quickly show up irregularities and second, the two-frit type would act as a check enamel against the other.

Sheet Steel:

20-gage plates $6^1/_2$ by $11^1/_4$ inches

Pickling Solutions:

Cleaner—Colloidal caustic 6 oz./gal. (boiling)
Acid { HCl—12% by weight (cold)
{ H_2SO_4—5% by weight (approx. 180°F)
Soda—0.30 oz./gal.
Borax—0.7 oz./gal.
Compounded neutralizer { Borax—0.3 oz./gal.
{ Soda—0.3 oz./gal.

It is here noted that the same conditions were maintained for both types of ground coat as to fineness, dipping weight, and time and temperature of firing.

IV. Results

It is sufficient to state here that the two-frit type of ground coat showed no defects throughout the range of variations in pickling procedure. The following tabulation of results on the single-frit type of ground coat shows the effect of lapsed time between steel mill pickling and the enameling process. This is shown by the varying degree of copperheading resulting from the condition of the metal.

Group I

Procedure to clean: (1) cleaner (2) rinse

(*A*) Pieces enameled 6 weeks after cleaning (steel aged).
(1) Nos. 1 to 3: single-frit old type.
(*a*) All pieces showed a medium degree of copperheading.

(*B*) Pieces enameled directly after cleaning.
(1) Nos. 55 to 57: single frit.
(*a*) All pieces showed a medium degree of copperheading.

(*C*) Pieces enameled directly after cleaning; enamel aged 5 days.
(1) Nos. 109 to 111: single frit.
(*a*) All pieces showed a medium degree of copperheading.

(*D*) Steel aged 6 weeks after cleaning; enamel aged 5 days.
(1) Nos. 163 to 165: single frit.
(*a*) Medium copperheading.

GROUP II

Procedure to clean: (1) cleaner (2) rinse (3) acid (4) rinse

(*A*) Pieces enameled 6 weeks after cleaning (steel aged).
(1) Nos. 7 to 9: hydrochloric acid } single-frit
(2) Nos. 13 to 15: sulfuric acid } old type.
(*a*) All pieces showed quite severe copperheading.

(*B*) Pieces enameled directly after pickling.
(1) Nos. 61 to 63: hydrochloric acid } single-frit
(2) Nos. 67 to 69: sulfuric acid } old type.
(*a*) All pieces showed quite severe copperheading.

(*C*) Pieces enameled directly after pickling with 5-day aged enamel.
(1) Nos. 115 to 117: hydrochloric acid } single-frit
(2) Nos. 121 to 123: sulfuric acid } old type.
(*a*) All pieces showed quite severe degree of copperheading.

(*D*) Steel aged 6 weeks; enamel aged 5 days.
(1) Nos. 169 to 171: hydrochloric acid } single-frit
(2) Nos. 175 to 177: sulfuric acid } old type.
(*a*) All pieces showed quite severe copperheading.

GROUP III

Procedure to clean: (1) cleaner (2) rinse (3) acid (4) rinse (5) soda

(*A*) Pieces enameled 6 weeks after cleaning.
(1) Nos. 19 to 21: hydrochloric acid } single-frit
(2) Nos. 25 to 27: sulfuric acid } old type.
(*a*) Sulfuric-acid group showed more severe copperheading than HCl group.

(*B*) Pieces enameled directly after pickling.
(1) Nos. 73 to 75: hydrochloric acid } single-frit
(2) Nos. 79 to 81: sulfuric acid } old type.
(*a*) All pieces showed about medium copperheading.

(*C*) Pieces enameled directly after pickling; enamel aged 5 days.
(1) Nos. 127 to 129: hydrochloric acid } single-frit
(2) Nos. 133 to 135: sulfuric acid } old type.
(*a*) All pieces showed about medium copperheading.

(*D*) Pieces aged 6 weeks; enamel aged 5 days.
(1) Nos. 181 to 183: hydrochloric acid } single-frit
(2) Nos. 187 to 189: sulfuric acid } old type.
(*a*) All pieces showed about medium copperheading.

GROUP IV

Procedure to clean: (1) cleaner (2) rinse (3) acid (4) rinse (5) soda (6) borax

(*A*) Pieces enameled 6 weeks after pickling.
(1) Nos. 31 to 33: hydrochloric acid } single-frit
(2) Nos. 37 to 39: sulfuric acid } old type.
(*a*) Sulfuric-acid group more severe copperheading than HCl group.

(*B*) Pieces enameled directly after pickling.
(1) Nos. 85 to 87: hydrochloric acid } single-frit
(2) Nos. 91 to 93: sulfuric acid } old type.
(*a*) All pieces showed only slight copperheading.

(*C*) Pieces enameled directly after pickling; enamel aged 5 days.
(1) Nos. 139 to 141: hydrochloric acid } single-frit
(2) Nos. 145 to 147: sulfuric acid } old type.
(*a*) All pieces showed only slight copperheading.

(*D*) Pieces aged 6 weeks; enamel aged 5 days.
(1) Nos. 193 to 195: hydrochloric acid } single-frit
(2) Nos. 199 to 201: sulfuric acid } old type.
(*a*) Sulfuric-acid group showed more severe copperheading than hydrochloric-acid group.

GROUP V

Procedure to clean: (1) cleaner (2) rinse (3) acid (4) compounded neutralizer.

(*A*) Pieces enameled 6 weeks after pickling.
(1) Nos. 43 to 45: hydrochloric acid } single-frit
(2) Nos. 49 to 51: sulfuric acid } old type.
(*a*) sulfuric-acid group showed more severe copperheading than HCl group.

(*B*) Pieces enameled directly after pickling.
(1) Nos. 97 to 99: hydrochloric acid } single-frit
(2) Nos. 103 to 105: sulfuric acid } old type.
(*a*) Sulfuric-acid group showed less copperheading than HCl group.

(*C*) Pieces enameled directly after cleaning; enamel aged 5 days.
(1) Nos. 151 to 153: hydrochloric acid } single-frit
(2) Nos. 157 to 159: sulfuric acid } old type.
(*a*) Sulfuric-acid group showed less copperheading than HCl group.

(*D*) Pieces aged 6 weeks; enamel aged 5 days.
(1) Nos. 205 to 207: hydrochloric acid } single-frit
(2) Nos. 211 to 213: sulfuric acid } old type.
(*a*) Sulfuric-acid group showed more severe copperheading than HCl group.

V. Summary of Results and Conclusions

(1) Occlusion of Cleaner An inspection of results tabulated under the data shows no indication that copperhead may be traced to residual cleaner in the pores of the metal.

(2) Occlusion of Acid-Pickle Aging of Steel and Kind of Acid The aging of steel after pickling seemed to increase the quantity and size of copperheads. This condition was more pronounced with sulfuric-acid pickle than with the hydrochloric-acid pickle. However, without aging, the sulfuric pickle gave superior results. These conditions would seem to indicate that acid, during the pickling operation, is absorbed by sheet steel, and that possibly the reaction between metal and acid (absorbed) goes to an end, over a long period of time, to give the corresponding salts of iron; that these latter react with the enamel during firing to give copperheads. It is highly possible that the reason that sulfuric-acid pickel is superior to HCl when the steel is not aged is because H_2SO_4 is less active in the cold than HCl. That free acid should remain in the pores of the metal rather than being neutralized by the alkaline wash seems offhand highly improbable. Moreover, it is not the purpose of this investigation to prove that free acid actually does exist in the pores of pickled

sheet steel; the results as already enumerated, however, seem to point in that direction.

(3) Kind of Neutralizer From the results it may be concluded that the type of neutralizer (whether soda, borax, or both) has no effect upon the copperheading.

(4) Age of Enamel The enamel, whether aged five days or milled fresh showed no difference in the fired application.

(5) Fluid and Viscous Ground Coat As evidenced in the data, a fluid ground coat is less likely to copperhead, under the conditions imposed, than a viscous ground coat. In fact, the fluid one, composed of two frits, showed no inclination to copperhead in any of the group conditions studied.

VI. Summary

As explained above, enameling usually takes place within twenty-four hours of the pickling of the steel in most enameling plants. The aging period of six weeks allowed in this work between the pickling and enameling of the metal was done in order to simulate conditions occurring when steel is pickled at the mill and then shipped from stock to the enameling plant.

The noncopperheading results of the two-frit type of ground coat of present-day use is an indication of what the enameler has done in the manipulation of his enamels in order to overcome defects resulting from conditions over which he has no control.

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THE GRAPHICAL COMPUTATION OF OPACITY OF PORCELAIN ENAMELS*

BY G. H. McINTYRE

ABSTRACT

The use and calculation of reflectivity data in connection with opacity is discussed.

I. Introduction

The general subject of opacity of porcelain enamels has received considerable attention in the literature during recent years.[1] This has been brought about by the rapid strides in the development of opaque enamels and the introduction of various types of opacifiers. The accurate comparison of opacity data for the finished enamel surface has been of extreme importance to the general enamel industry. It has generally been the custom to plot curves for such variables as weight of coating per unit area or thickness of application and amount of opacifier used, without regard to the fact that these data may follow definite mathematical curve forms. Unless this is taken into consideration, it is believed that inaccuracies of measurement or possible significant variations from the fundamental curve forms often escape the attention of the experimenter.

When a smooth curve can be drawn so as to pass through or very near the observed points, we may suspect that some relation may exist which can be expressed mathematically by the equation of the curve. The true relation will be represented only approximately since the original measurements, the plotting of the points, and the drawing of the curve are all approximations. Hence, any equation or formula to express this relationship is known as an empirical formula and should be distinguished from an equation which expresses a physical or chemical law. Such empirical formulas are often used in engineering sciences for the purposes of interpolation, *i.e.*, for computing the value of one of the quantities when the value of the other is given within the range of values used in determining the formula. Often the form of the curve will suggest the type of equation and having chosen the form it may be tested by "rectifying" the curve, *i.e.*, by writing the assumed equation in the form

$$(a)\ f(y) = a + bF(x) \text{ or}$$
$$(b)\ y' = a + bx'.$$

Where $y' = f(y)$ and $x' = F(x)$; plotting the points with x' and y' as coördinates.

If the points of this plot appear to lie on a straight

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* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (Enamel Division). Received February 14, 1934.

[1] (*a*) L. Stuckert, *Glashütte*, **62** [45], 798–801 (1932). (*b*) O. Knapp, *Sprechsaal*, **65** [39], 707–708 (1932). (*c*) A. I. Andrews, G. L. Clark, and H. W. Alexander, *Jour. Amer. Ceram. Soc.*, **16** [8], 385–92 (1933). (*d*) G. H. McIntyre, J. T. Irwin, and M. G. Ammon, *ibid.*, **16** [7], 338–41 (1933). (*e*) Private correspondence.

line or very near to it, then this line can be expressed by equation (*b*) and hence the original curve by equation (*a*).[2]

Since the equations are empirical, other equations may be so chosen as to fit the data equally as well, but the equation chosen should always be one of as simple a form as possible. It is believed that the equations described in this paper will be found simple in form and easy to use and, as will be shown, will fit the data exceedingly well.

The opacity or "hiding power" of an enamel is known to be directly related to the reflection factor of the surface. Taylor[3] aptly describes the nature of reflection for surfaces in general:

> The reflection factor of a surface is defined as the ratio of the total luminous flux reflected by the surface to the total luminous flux incident upon it.
>
> The surface may be illuminated by a narrow beam of light, by light from several directions, by totally diffused light, or by some combination of these. Reflection may take place in many ways, *e.g.*, specular reflection, in which case an incident cone of light is reflected as a cone, the angles of incidence and reflection being equal; perfectly diffused reflection, in which case the light is reflected in all directions in accordance with the cosine law† of emission; mixed specular and diffused reflection, in all possible combinations between the extremes.
>
> No surface obeys the cosine law of emission perfectly, and most surfaces are very far from being perfect diffusers.

† The cosine law of emission states in substance that the light is reflected from a perfectly diffusing surface in such a manner that the luminous intensity (expressed in candle power or by some similar unit) of an element of area at any angle of emission is equal to the intensity normal to the surface multiplied by the cosine of the angle between the line of emission and the normal to the surface. This assumes that the intensity at any angle is directly proportional to the projected area of the element of surface, hence that the surface brightness (candles per unit area) is constant at all angles.

This law has often been erroneously referred to as Lambert's cosine law. A. P. Trotter has recently shown that Lambert's law refers to the *incident* light instead of the *reflected* light, and that this law states that the intensity of *illumination* of any surface varies as the cosine of the angle between the line of incidence and the normal to the surface. Hence it is seen that Lambert's cosine law is rigidly correct.

Porcelain enamel surfaces show both specular and diffused reflection but, if properly measured, the reflectivity factor is a direct expression of opacity. O. Knapp[1b] has shown that this relationship may be expressed by the following equation:

$$R = 100 - (D + A) \qquad (1)$$

Where D = % light transmission
A = % light absorption
R = % reflectivity

[2] Jos. Lipka, Graphical and Mechanical Computation, pp. 120–52. John Wiley & Sons, 1918.
[3] Taylor, *U. S. Bur. Stand. Sci. Paper*, No. 391.

Data for this paper have been taken at random from a large number of such measurements and represent an average cross-section of the results obtained. Data gathered from experimenters in various laboratories, using various types of reflectivity-measuring devices on all types of wet-process cover-coat enamels are included. In our own laboratory, we employ a Taylor reflectometer.[4] At least over a practical range of weight of application of the enamel, we have found that the curve forms presented are independent of the enamel and the method of measurement, provided the latter is correct in principle.

II. Curve Forms

(1) Variation in Weight or Thickness of Application, Other Variables Constant

Keeping the enamel, amount and kind of opacifier, clay, fineness of milling, specific gravity, and firing conditions constant, the reflectivity as a function of weight of coating has been found to be approximately expressed by the empirical equation typical of hyperbolic curves.

$$R = \frac{W}{mW + b} \qquad (2)$$

Where R = reflectivity (%).
W = weight (or thickness) of application per unit area. This has been expressed in the mixed system units of g./sq. ft., as this method lends itself to the convenience of the average laboratory and avoids the use of fractions.
b = a constant, depending on the natural opacity; *i.e.*, absorption and transmission properties of the fired enamel.
m = a constant, also depending on the natural opacity, *i.e.*, absorption and transmission properties of the fired enamel.

For thickness, T, in millimeters (or inches), can be substituted for W, since thickness is directly related to unit weight of appliction,[1d] and the constants m and b determined accordingly.

The limiting value or highest opacity theoretically possible at any weight (or thickness) is given by the expression

$$R = 1/m \qquad (3)$$

This serves as a rough check on the accuracy of the determination of m. Since R must always be lower than 100%, m can never numerically be less than 0.010+.

Equation (2) can be treated as an equation of the first degree by plotting Y against W.[5]

Where $Y = W/R$

[4] Taylor, *U. S. Bur. Stand. Sci. Paper*, No. 405.
[5] Jos. Lipka, *loc. cit.*, pp. 137–39.

The plot of this line will then be expressed by the simple equation

$$Y = mW + b \qquad (4)$$

The general equation for any straight line is

$$y = mx + b$$

Where m = the slope (tangent of angle to x axis)

b = a constant locating position of line on y axis

In the graphical method of computation, m can be determined by dividing the ordinate by the abscissa. The most practical way is to start with any point on the line near the lower end and

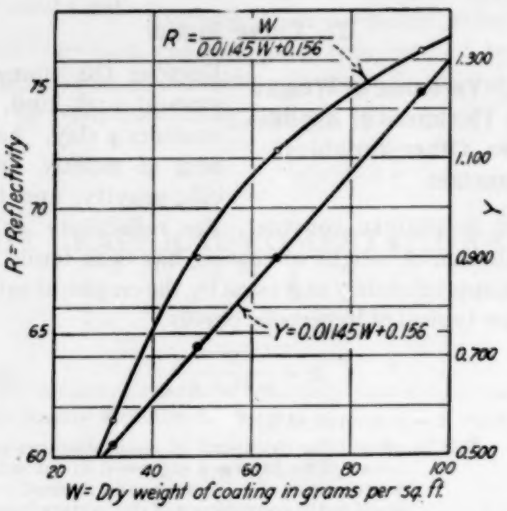

FIG. 1.—Typical calculation for curve form.

$$R = \frac{W}{mW + b}$$

Constants from data for enamel No. 10, Table I.

From straight-line plot

$$\text{Slope } m = \frac{11.45}{10} \times \frac{0.50}{5}$$
$$= 0.01145$$
$$b = 0.956 - 0.01145\,(70)$$
$$= 0.156$$

From method of averages

$$\Sigma W/R = m\Sigma W + nb$$
$$1.242 = m81 + 2b$$
$$2.131 = m159 + 2b$$
$$m(159 - 81) = 2.131 - 1.242$$
$$m = 0.01140$$
$$b = \frac{1.242 - 0.923}{2}$$
$$= 0.159$$

count 10 divisions on the x axis, count the number of divisions up until the line is crossed, and divide this value of Y by 10, converting to the proper units used for the scale on the graph.

The b constant is determined by substituting any value of x and y on the line in the equation and solving for b, having first determined m.

This procedure is of value in checking the accuracy of a series of determinations and is also of aid in determining the constants from the experimental data. By plotting Y against W in equation (4) on accurate coördinate paper, the experimental data should be expressed by a straight line. See Fig. 1 for a typical example. It has been found from experience that any values which do not fall on the straight line are either in error or are deviations from the theoretical hyperbolic curve (2) which normally expresses this relationship. Such deviations often have a significant meaning and will be further discussed.

(2) Variation in Amount of Opacifier, Other Variables Constant

Keeping the kind of frit, weight of application per unit area, clay, fineness of milling, specific gravity, and firing conditions constant, the relationship between reflectivity and amount of opacifier used has been found to follow the curve form of the empirical formula

$$R = ax^d + C \qquad (5)$$

which is the equation of a parabolic curve.

Where R = reflectivity (%)

x = amount of opacifier expressed as weight per cent of frit.

a = a constant depending on frit and weight of application.

d = a constant depending on frit and independent of weight of application within practical limits.

C = a constant, which is reflectivity value with no opacifier in enamel at particular weight or thickness being studied.

The C constant can be determined experimentally for any particular enamel.

In order to reduce the curve of equation (5) to a straight line, the logarithmic form can be used as follows:

$$\text{Log } (R - C) = \log a + d \log X \qquad (6)$$

Equation (6) is the straight-line form where

$$y = \log (R - C)$$
$$m = d$$
$$b = \log a$$
$$x = \log X$$

By calculating the values of log $(R - C)$ and plotting as y against log X, the points, if following this curve form, will fall on a straight line. The b constant (log a) is then determined by substituting any value of log $(R - C)$ and log X that falls on the line and solving for log a, having first determined d as the slope or tangent.

A typical calculation is shown in Fig. 2.

It is generally considered that a graphical proof such as given for the equations (2) and (5) is

inadequate, but many of the results have been verified by other mathematical means such as the method of averages and the method of least squares. It has been found that the graphical method is within the accuracy of the errors of experiment and is satisfactory for all practical purposes.

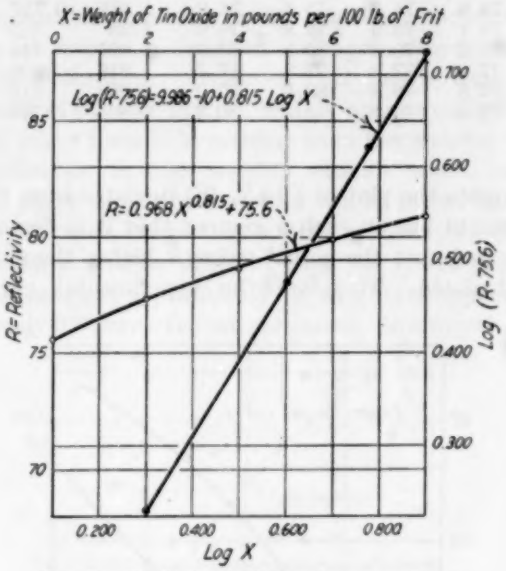

FIG. 2.—Typical calculation for curve form.

$$R = aX^d + C$$

Constants from data for enamel No. 5, Table II.

From straight-line plot

$$\log (R - C) = \log a + d \log X$$

$$\text{Slope } d = \frac{16.3}{10.0} \times \frac{0.025}{0.050}$$

$$= 0.815$$

$$0.555 = \log a + 0.815\ (0.700)$$

$$\log a = 0.557 - 0.571$$

$$= 9.986 - 10$$

$$a = 0.968$$

III. Experimental Evidence

Comparison of experimental and calculated values of reflectivity for given weights is shown in Table I for the expression

$$R = \frac{W}{mW + b} \qquad (2)$$

This represents different types of cover-coat enamels on both white and dark ground coats. The mean variation of the calculated value from the experimental, omitting those obviously affected by the ground coat at low weights of application, is only ±0.37%. The accuracy of the determinations made on the Taylor reflectometer are within only ±0.5%. Hence the reflectivity values calculated from the experimentally determined constants are well within the limits of error.

TABLE I

$$R = \frac{W}{mW + b}$$

Enamel No.	Weight of application (g./sq. ft.)	Reflectivity Exp.	Reflectivity Calc.	Deviation of calculated to experimental (%)	Av. deviation (%)	m	b
1	30.5	69.2	69.0	−0.29			
	48.0	75.2	75.2				
	63.5	77.9	78.3	+0.51			
	89.0	80.9	81.1	+0.25	±0.26	0.01120	0.100
2	31.1	53.9	57.4	6.5	omit; error due to		
	42.3	63.3	63.3		dark ground and		
	53.6	67.5	67.4	−0.15	weakly opaque enamel		
	65.3	70.1	70.4	+0.43			
	82.0	73.5	73.6	+0.14	±0.18	0.01125	0.192
3	40.5	66.8	69.5	+4.04	omit; effect of dark		
	49.5	72.7	72.8	+0.14	ground		
	60.0	75.8	75.8				
	70.5	77.8	78.0	+0.26			
	80.0	79.5	79.5		±0.060	.01070	0.150
	90.0	80.9	80.9				
4	42.0	73.1	73.8	+0.96			
	53.0	77.6	77.0	−0.77			
	64.0	79.8	79.2	−0.75			
	81.0	81.1	81.6	+0.62	±0.78	0.01086	0.113
5	29.5	72.2	66.3	−8.20	omit; effect of white		
	53.0	76.3	76.4	+0.39	ground		
	64.0	79.1	79.3	+0.25			
	80.0	81.8	82.0	+0.24	±0.29	0.01050	0.135
6	30.0	61.9	66.1	+6.8	omit; effect of dark		
	41.0	69.9	70.1	+0.29	ground		
	52.5	73.3	73.2	−0.14			
	63.0	75.1	75.1				
	79.0	77.1	77.1		±0.11	0.01158	0.110
7	40.0	65.6	68.1	3.8	omit; effect of dark		
	50.0	71.8	71.7	−0.14	ground		
	60.0	73.9	74.0	0.14			
	70.0	76.1	76.1				
	80.0	77.9	77.7	−0.26	±0.14	0.01107	0.145
8	30.8	62.7	62.9	+0.32			
	61.0	75.1	74.9	−0.27			
	64.0	75.9	75.6	−0.40			
	93.2	80.0	80.3	+0.38	±0.34	0.01077	0.158
9	32.0	58.9	58.3	−1.02			
	48.0	65.2	65.6	+0.61			
	64.0	69.7	70.2	+0.72			
	92.0	75.2	74.8	−0.53	±0.72	0.01137	0.185
10	32.0	61.4	61.2	−0.33			
	49.0	68.0	68.4	+0.69			
	65.0	72.3	72.2	−0.14			
	94.0	76.3	76.2	−0.13	±0.32	0.01145	0.159
11	35.0	54.8	55.3	+0.91			
	53.0	65.0	64.6	−0.61			
	77.0	71.6	71.9	+0.42			
	89.0	74.5	74.3	−0.27	±0.55	0.01048	0.271
12	30.5	62.2	62.1	−0.16			
	64.6	74.1	74.5	+0.54			
	91.5	78.4	78.7	+0.38			
	120.8	81.3	81.3		±0.27	0.01102	0.157
13	30.5	60.6	60.6				
	42.5	68.4	67.7	−1.02			
	53.0	71.3	71.9	+0.84			
	64.0	75.2	75.1	−0.13			
	85.0	78.9	79.4	+0.63	± 0.52		
			Mean deviation		± 0.37%		

III. Experimental Evidence

Comparison of experimental and calculated values of reflectivity for given weights is shown in Table I for the expression

$$R = \frac{W}{mW + b} \qquad (2)$$

This represents different types of cover-coat enamels on both white and dark ground coats. The mean variation of the calculated value from the experimental, omitting those obviously affected by the ground coat at low weights of application, is only ±0.37%. The accuracy of the determinations made on the Taylor reflectometer are within only ±0.5%. Hence the reflectivity values calculated from the experimentally determined constants are well within the limits of error.

TABLE II

$R = aX^d + C$

% tin oxide (X) =

Enamel No.	0 Exp.	0 Calc.	2 Exp.	2 Calc.	4 Exp.	4 Calc.	6 Exp.	6 Calc.	8 Exp.	8 Calc.	a	d
1	68.1	68.5	70.9	71.1	73.3	72.9	74.8	74.5	75.6	75.9	1.548	0.757
2	62.3	62.3			71.4	71.6	74.1	73.9	75.8	76.0	4.28	.557
3	75.3	75.3			78.2	78.1	79.2	79.2	80.1	80.0	1.025	.744
4	73.4	73.4	75.8	75.8	76.8	76.8	77.0	77.2	77.6	77.7	1.812	.409
5	75.6	75.6	77.3	77.3	78.6	78.6	79.8	79.8	80.8	80.9	0.968	.815
6	77.9	77.9	78.7	78.7		79.3	79.8	79.8		80.3	0.463	.788

Mean deviation = ±0.12%.

Since the constants are calculated from an average of all the determinations, the calculated curve is more accurate than the individual experimental figures.

Table II gives a comparison between calculated and experimental values for several enamels of different types for the equation

$$R = ax^d + C. \qquad (5)$$

Here the mean percentage deviation of the twenty-six determinations is only ±0.12% which shows how exceedingly well data of this kind follow the parabolic curve form.

IV. Practical Applications

(1) Effect of Ground Coat Deviations from the true hyperbolic curve will occur at the lower weights of application depending on the type of ground coat used. The more opaque the enamel, the less this variation will be.

(a) Dark Ground Coats For dark ground coats this variation will amount to between 1 and 2%, the experimental value being lower than the calculated value. This variation extends over a large range of weight of application with weakly opaque enamels, and over only a very narrow range at the lower weights with highly opaque enamels. Above 50 grams per square foot, the calculated and experimental values for most enamels have been found to agree very well, regardless of amount of natural opacity. Figure 3 shows a typical example.

(b) White Ground Coats The data obtained to date show that an enamel of high inherent opacity follows the same curve (constants of the equation are the same) when applied over a white ground as when applied over a blue ground, except at weights of the order of 30 grams per square foot. At these weights the plot of (W/R, W) deviates from the straight line in such a manner that it is demonstrated that the actual value is higher than the calculated. Therefore the experimental curve

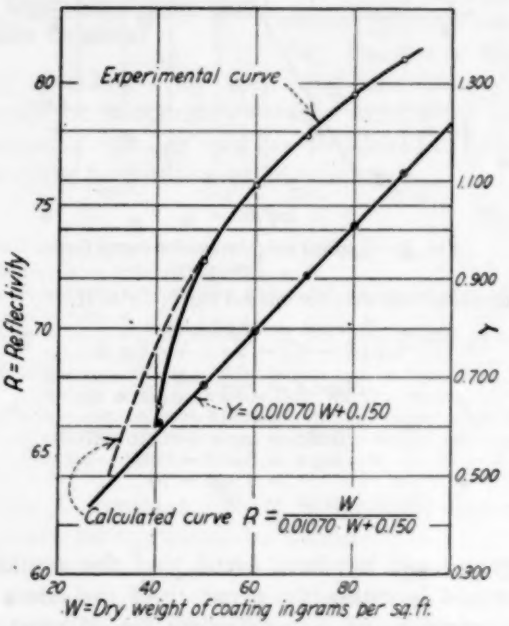

FIG. 3.—Effect of blue ground on some enamels.

$$R = \frac{W}{mW + b}$$

Constants from data for enamel No. 3, Table I.

From straight-line plot

$$\text{Slope } m = \frac{10.7(0.05)}{10.0(5)} = 0.01070$$

$$b = 0.850 - 0.01070\,(65.5) = 0.150$$

From averages (omitting value 40 grams)

$$\Sigma W/R = m\,\Sigma W + nb$$

$$2.378 = 180m + 3b$$

$$2.118 = 170m + 2b$$

$$b = \frac{2.378 - 180m}{3} = \frac{2.118 - 170m}{2}$$

$$m = \frac{6.354 - 4.756}{150} = 0.01068$$

$$b = \frac{2.378 - 180(0.01068)}{3} = 0.152$$

deviates from the true hyperbola as shown on Fig. 4.

It is believed that if the reflectivity values could be accurately measured at very low weights of application (exceedingly thin coatings), the curve would reverse in direction and again assume the hyperbolic form. Evidence that this is true is found in the fact that for weakly opaque enamels, the curve form is hyperbolic from low weights of application to high weights without break, but the curve on a white ground will be higher than for the same enamel on a dark ground, *i.e.*, the constants will be different over the entire practical range of application. At weights of approximately 100 grams the two curves will come together.

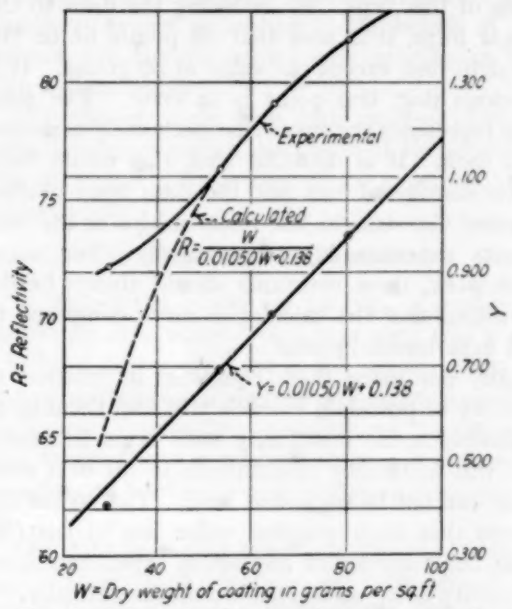

FIG. 4.—Effect of white ground on some enamels.

$$R = \frac{W}{mW + b}$$

Constants from data for enamel No. 5, Table I.

From straight-line plot

$$\text{Slope } m = \frac{10.5}{10} \times \frac{0.05}{5} = 0.0105$$
$$b = 0.765 - 0.0105(60)$$
$$= 0.135$$

From these considerations it would seem impractical to employ a white ground with a very opaque cover-coat enamel, unless extremely thin applications could be accurately controlled.

(2) Rapid Determination of Curves for Comparison of Enamels or Opacifiers

It is often necessary to compare the reflectivity properties of various enamels or opacifiers. Considerable time and effort is required for the complete determination of the curves experimentally. By the use of the mathematical relationships involved these curves can be determined accurately and quickly.

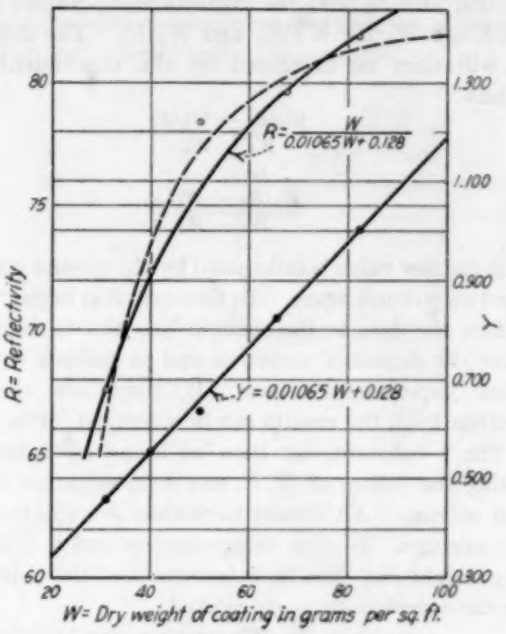

FIG. 5.—Effect of point in error. Constants (from data below).

From straight-line plot

$$\text{Slope } m = \frac{10.65 \times 0.05}{10 \times 5}$$
$$= 0.01065$$
$$b = 0.900 - 0.01065\,(72.5)$$
$$= 0.128$$

From method of averages (omitting experimental value at 50 grams per square foot)

$$\Sigma W/R = m\,\Sigma W + nb$$
$$1.012 = 71m + 2b$$
$$1.819 = 147m + 2b$$
$$b = \frac{1.012 - 71m}{2} = \frac{1.819 - 147m}{2}$$
$$m = \frac{0.807}{76}$$
$$= 0.0106$$
$$b = 0.129$$

Data

W	R(exp.)	R(calc.)
31.0	67.6	67.7
40.0	72.4	72.2
50.0	78.4	75.8
65.5	79.6	79.4
82.0	81.8	82.0

A still simpler way of determining the constants than the graphical method described before can be employed for rapid determinations.

(a) Weight Curves In this case the reflectivity can be carefully determined by measurement at two or three weights of ap-

plication, one near the upper limit, one at the medium weight, and one near the lower limit of practical weight.

Let these be W_3, W_2, and W_1, respectively, then the corresponding reflectivity values will be R_3, R_2, and R_1 and the corresponding values of W/R are W_3/R_3, W_2/R_2, and W_1/R_1. The slope m will then be expressed by the experimental values

$$m = \frac{W_3/R_3 - W_2/R_2}{W_3 - W_2}$$

or

$$\frac{W_2/R_2 - W_1/R_1}{W_2 - W_1}$$

If the low value is influenced by the ground coat the two will not agree. In this case it is better to reduce the data to the straight-line plot to determine the degree of variation and to recheck with more experimental data. If they are close (within 1%), the results can be averaged for m.

The b constant can then be found by substituting the values of W, R, and m in equation (2) and solving. All should be within $\pm 0.5\%$ from the average. Having determined m and b, R for any weight can then be calculated and the points for the complete curve calculated.

(b) Opacifier Curves The same general method can be used for solving equation (5) from few experimental data. The constant, C, is first determined by carefully obtaining the value of R at the particular weight being studied with no opacifier present. If it is desired, this can be calculated for any given weight from equation (2), having first determined the constants m' and b' for the frit plus clay, *i.e.*, no opacifier present in the liquid enamel.

Having determined C either experimentally or by calculation, R is experimentally determined for any two values of X, preferably 2% and 8% opacifier. The slope d of the straight-line form (6) then becomes

$$d = \frac{\log (R_2 - C) - \log (R_1 - C)}{\log X_2 - \log X_1}.$$

Substituting this value of d and the experimental values of R and X in equation (6), $\log a$ is calculated. From the values of a and d thus obtained, the value of R for any amount of opacifier can be calculated from equation (5) or the simpler logarithmic form (6).

(3) Determining Accuracy of Experimental Points Figure 5 is an interesting example of a set of data having one point seriously in error. The dotted line is an average curve (an approximation of the data) that normally would be drawn without consideration of the mathematical aspects of data of this type. By reducing the data to the linear form, it is seen that all points lie on the straight line, except the value at 50 grams. It is obvious that this point is in error. The solid line represents the curve that accurately expresses the data. It is doubtful that this would have been discovered had not the data been plotted against the straight-line relationships or the constants determined mathematically. For accurate work, these constants should always be determined and the calculated curve compared to the experimental points.

Any one using these equations in relation to opacity of porcelain enamels will find them more valuable as his familiarity with them increases. He will find many applications to his own work that can not be suggested here. The writer believes that their greatest value lies in the fact that the accuracy of any set of experimental reflectivity data can be checked mathematically.

Acknowledgment The author wishes to thank J. T. Irwin of his staff for his aid in developing the weight variable equations.

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CONDENSABLE VAPORS IN A TANK FURNACE MELTING A SALTCAKE BATCH*

By J. S. Gregorius and W. A. Mahaffey

ABSTRACT

Vapors arising from the surface of a tank melting a saltcake batch were collected on water-cooled condensers. The condensates were analyzed and these data, together with analyses of checker chamber slag and flue débris, permitted certain interpretations of superstructure corrosion by vapors.

I. Introduction

Superstructure[1] corrosion in a glass tank has to a great extent been commonly attributed to batch dusting. To a degree this does occur, but the predominant agents, according to the beliefs of the writers, are the vapors actually existing in the furnace atmosphere.

The present paper deals with analyses of these vapors together with a discussion of the probable rôle they play in the erosion of the superstructure refractories.

II. Experimental Procedure

To collect the vapors for analysis, a condenser consisting of a water-cooled iron pipe was used. The condenser was placed in the selected position and permitted to remain for forty-eight to ninety-six hours. It was then removed and the condensate scraped into a vial which was sealed with paraffin and later subjected to quantitative analysis.

The data presented here were collected from a regenerative tank furnace in production of "Penn Vernon" window glass, which was melting a saltcake batch at the rate of 100 tons for twenty-four hours. These data and interpretations can well apply to most any commercial glassmelting furnace melting a similar batch.

The positions in the tank furnace where these vapors were collected are shown in Fig. 1.

To augment these condensate analyses, slags formed on top of the checker brick under the first, second, and third ports were obtained, and flue dust and débris were collected from the crown, walls, and floor of the flues at two different positions. One flue position was halfway between air valve and checker chamber and the other position was directly under the air valve.

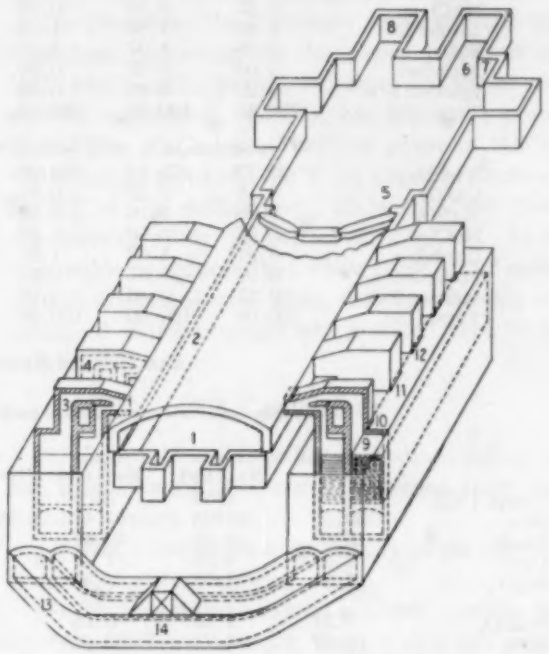

Fig 1.

III. Results of Analyses

The analyses of the various specimens follow, and the normal operating temperature is indicated (see Table I).

To complete the picture, the glass composition being produced and the analyses of the refractory used in the port and regenerator linings are also given in Table I.

IV. Discussion

A study of these analytical data permit the following interpretations:

(1) The bulk of the condensable vapors arising from this type of batch is sodium sulfate. The fact that all condensates give a mild alkaline reaction definitely shows the absence of free sulfuric anhydride.

(2) It is striking that the concentration of NaCl is low in all condensates collected in the firing

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[1] This term, "superstructure," tacitly includes ports, necks, and checkerwork; in fact, all structure connecting the basin or hearth to the chimney and to the valves.

TABLE I

ANALYSES OF VAPOR CONDENSATES

	1 Between fill dog houses 5–7 in. above glass	2 Between 3rd and 4th ports right side 5–7 in. above glass	3 Through No. 1 port peephole right side across air uptake	4 Through No. 2 port peephole right side across air uptake	5 Through glass measuring hole approx. 5 ft. in front of floater hole	6 Through right wall 1 foot from front wall 18 in. above glass	7 Through right wall 1 foot from front wall 5–7 in. above glass	8 Large sheet coolers; back and front; chiefly front kiln 5
Temp. (°C)	1400	1480	1290	1310	1370	1240	1240	1090
Na_2SO_4	92.91	94.97	91.05	97.15	92.68	90.88	91.94	87.79
$CaSO_4$	3.14	1.14	0.53	1.21	1.36	0.49	0.41	0.49
$MgSO_4$	0.48	0.18	0.12	0.24	0.24	0.45	0.06	0.12
NaCl	0.37	0.52	0.55	0.40	4.26	4.43	3.93	6.51
Insoluble	3.02	1.66	1 82	0.22	1.22	1.14	1.20	1.58
R_2O_3	0.28	1.04	5.10	0.34	0.42	1.28	1.20	0.64
Moisture	0.06	0.07	0.20	0.07	0.02	0.22	0.16	0.50
Ignition loss	0.22	0.46	0.66	0.29	0.21	0.90	0.74	1.58
Total (%)	100.48	100.04	100.03	99.92	100.41	99.79	99.64	99.21
Recalculated to 100% without R_2O_3 (contamination from condensers)								
Na_2SO_4	92.73	95.95	95.90	97.57	92.69	92.25	93.39	89.07
$CaSO_4$	3.13	1.15	0.57	1.21	1.36	0.50	0.42	0.50
$MgSO_4$	0.48	0.18	0.13	0.24	0.24	0.46	0.06	0.12
NaCl	0.37	0.52	0.58	0.40	4.26	4.50	4.00	6.60
Insoluble	3.01	1.67	1.91	0.22	1.22	1.16	1.22	1.60
Moisture	0.06	0.07	0.21	0.07	0.02	0.22	0.16	0.51
Ignition loss	0.22	0.46	0.70	0.29	0.21	0.91	0.75	1.60
Total (%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

ANALYSES OF REGENERATOR CONDENSATES

	9 Débris from top of first course checker packing	10	11	12	13 Débris from air tunnel	14	15	
	Front end door	Under No. 1 port	Under No. 2 port	Under No. 3 port	Half way between regenerators and air valve	3 ft. from stack tunnel (under air valve)	Benezet fire brick	Glass composition
Temp. (°C)	1065	1150	1200	1200	680	540	SiO_2 54.21	SiO_2 72.13
SiO_2	48.30	41.08	42.45	44.89	8.08	6.69	Al_2O_3 38.60	Na_2O 13.65
Na_2O	18.60	18.83	20.37	19.71	28.58	30.31	Fe_2O_3 2.15	CaO 9.88
CaO	1.38	4.36	1.72	1.04	7.76	7.30	TiO_2 2.20	MgO 3.18
MgO	1.84	1.73	1.35	2.31	2.02	1.50	CaO 0.17	Na_2SO_4 0.71
Na_2SO_4	0.31	2.25	0.15	0.43	SO_3 46.65	SO_3 46.58	MgO 0.38	NaCl 0.11
R_2O_3	34.07	31.75	33.96	31.62	5.31	6.31	Na_2O, K_2O } 2.44	R_2O_3 0.34
Ignition loss					1.60	1.31	0.08	
Total (%)	100.00	100.00	100.00	100.00	100.00	100.00	100.23	100.00

chamber when compared to the cooling chamber and forehearth condensates. A realization of NaCl vapor pressure at these temperatures shows that NaCl must be rising in the firing chamber as well as in the cooling chamber. The only explanation to offer for this irregularity follows: In the vapor phase there is molecular freedom. In the firing chamber (natural gas fuel CH_4), copious quantities of water vapor exist in the products of combustion. Hence it is reasonable to suspect that the union of H and Cl molecules has occurred and this HCl gas has not condensed (boiling point, 83.1°C) at the temperatures of the condenser which would probably be about 100°C.

(3) The analyses of the débris that collects in the flues are also predominantly sodium sulfate; the constituents SiO_2 and R_2O_3 occur in ratios similar to the refractory lining of flues and their presence can be ascribed to contamination entering the samples upon collection. There are evidences of CaO and MgO being present which undoubtedly can justly fall into the category of batch dust mechanically carried from the fusion hearth. It is interesting to note that this débris concentrates in that portion of the structure where temperatures from 1100 to 1400°C prevail.

(4) The slags that were collected from the top of the checker filling show a low content of sodium sulfate and high content of Na_2O with SiO_2 and R_2O_3 comprising three-quarters of the whole. Also the SiO_2–R_2O_3 ratios are comparable to the ratio that prevails in the composition of the refractory structure. The slag that forms on top of this checkerwork has its source from the lining of the port necks and port uptakes. Vapors similar to those condensed are considered to be acting on these refractory surfaces, forming slags which become fluid at the temperatures prevailing

and drain to points of lower temperature where they congeal. As these slags become further enriched in flux, their softening temperatures decrease, permitting them to descend to lower levels and temperatures and increasing, as they travel, their burden of SiO_2 and Al_2O_3 from the checkers themselves. It is interesting to note that these slags carry more CaO and MgO than were found in the condensates. Furthermore, the specimen collected under the first port shows the highest content of lime and magnesia. This indicates some dusting, but still the evidence is preponderant in indicating that vapors are playing the more destructive rôle.

(5) The following data were determined on alkali loss in tank melting. The calculated glass composition, based on raw material analyses averaged for four months and actual average glass composition over the same period as determined by analyses are given.

	Calculated	Actual
SiO_2	71.61	72.13
Na_2O	14.12	13.65
CaO	10.04	9.88
MgO	3.08	3.18
Na_2SO_4*	0.71	0.71
NaCl	0.18	0.11
R_2O_3	0.26	0.34
	100.00	100.00

* The quantity of the SO_3 radical found by actual analysis was calculated to Na_2SO_4 and so recorded in the calculated analysis. The remaining Na_2SO_4 in raw batch was then calculated to Na_2O and added to the Na_2O yield from the sodium carbonate in raw batch.

From these analyses it can be said that for the conditions prevailing in this particular melting unit, the Na_2O loss was 3.33%, using the calculated Na_2O content as a base. This loss in terms of pounds of Na_2CO_3 is 880 pounds per day. Also the total daily input of NaCl entering as impurities in soda ash and saltcake is 161 pounds per day, the quantity retained in the glass is 99 pounds per day, giving a loss by volatilization of 62 pounds per day. The total gas loss, including CO_2 and SO_3, from decomposition of carbonates and sulfates equals 29,000 pounds per day.

(6) Data on the volatility of glassmaking constituents are as follows: Howarth and Turner have shown that Na_2CO_3 with a melting point of 852°C has, at 1400°C, a vapor pressure of 66 millimeters Hg (International Critical Tables value at 1400°C is 25 millimeters Hg). By extrapolation, the vapor pressure at 1705°C is found to be 760 millimeters Hg. They also show that when one mol of Na_2CO_3 is mixed with 4 mols of SiO_2, the vapor pressure becomes 330 millimeters at 788°C.

Unfortunately the literature contains little information pertaining to the vapor pressures of NaCl and Na_2SO_4, but the following properties can well be mentioned. Na_2SO_4 has a melting point of 884°C. NaCl has a melting point of 805°C and a boiling point of 1439°C (or vapor pressure at 1439°C of 760 millimeters), all being lower than the corresponding properties of Na_2CO_3. It is reasonable to assume that when these latter compounds are mixed with silica, they too develop an enhanced vapor pressure which would raise their volatility.

V. Conclusions

(1) In a saltcake-type batch, sodium sulfate is the predominant substance condensed from the furnace vapors.

(2) NaCl condenses more readily in the relative absence of water vapor.

(3) Sodium-sulfate vapors actively corrode refractory surfaces forming slags which are semi-fluid at regenerator temperatures.

(4) Vapors from this type batch which are not spent on the refractories condense, at least in part, at temperatures of 1400°F and 1100°F, in the flue passages.

It is hoped that further investigation will be undertaken for collecting and analyzing vapors from tank furnaces in which batches of little or no saltcake content are used.

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STRESSES IN WIRE GLASS ARISING FROM THE WIRE*

By Frank W. Preston

ABSTRACT

This paper deals with the polariscopic appearance of certain types of wire glass having the wire set eccentrically in the thickness. The glass, being wholly in compression, appears at first sight to be out of equilibrium, but when the stress in the wire is taken account of, the distribution is seen to be normal.

A preliminary skirmish with this problem was presented two or three years ago.[1]

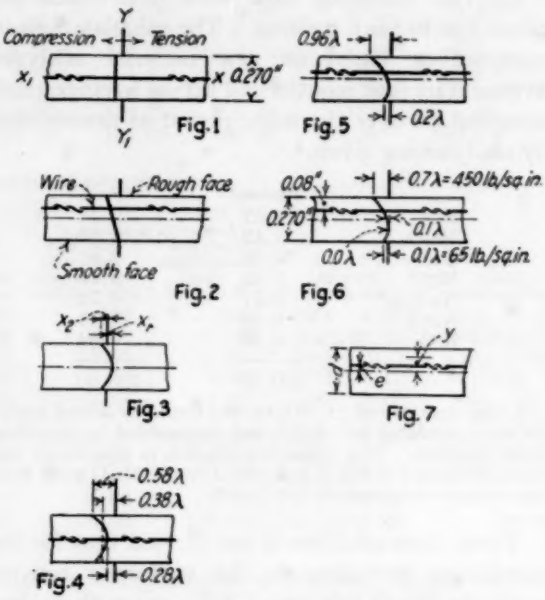
Recently the writer's attention was called by L. T. Sherwood to the peculiar distribution of stress through the thickness of the glass in wire glass produced by a continuous process, and he asked that a proper explanation be offered to glass technologists.

The glass in question is of standard thickness, viz., the nominal 1/4 inch, which is really about 0.270 inch or approximately 7 millimeters. It is said to be made by a "solid" process, that is, in the making only one stream of glass is involved and not two, as in the various "sandwich" processes. The wire is pronouncedly eccentric, being 0.08 to 0.09 inch from the "rough" face and at least twice as far from the "smooth" face. There is no objection of a scientific character to this, although central location of the wire used to be a talking point with some salesmen and was called for in the underwriters' specifications, which were presumably political rather than scientific in character.

The eccentric position of the wire is the key to the polariscopic appearance. It was shown in the previous paper[1] that if the wire were central, it might produce a general compression in the glass of the order of 250 pounds per square inch. Looking through the glass edgewise, the wire being central on the plane XX_1, the stress distribution would be as in Fig. 1, YY_1 being the axis of zero stress. If a Babinet compensator be used, the appearance of the central black line, which is virtually a graph of the stress under these conditions, would be as indicated in Fig. 1, that is, assuming optically perfect annealing.

The specimens examined were 1.95 inches long in the direction of the light path and, under these conditions, a displacement of 1 wave-length indicates a stress of about 650 pounds per square inch. A stress of 250 pounds per square inch would therefore displace the central Babinet line by 0.38λ, where λ stands, as usual, for a wavelength of sodium light, or in this case, the distance between consecutive Babinet bands when looking at a sodium flame.

But the wire is not central in these specimens; it is approximately one-third the thickness from the rough face and two-thirds the thickness from the smooth face. This figure happens to be a particularly convenient one for calculation, because it is known that in such a case the stress distribution becomes that shown in Fig. 2. At the smooth face the compression vanishes, and at the rough face it is twice what it was before, or 0.76λ. (We are still assuming perfect annealing.) The annealing in practice is not, however, optically perfect. In the absence of any wire, the stress distribution due to the annealing gradient would be a substantially parabolic curve as in Fig. 3. The glass would be in tension over the greater part of its thickness, namely the interior parts of the glass, and in compression near the edges.



EDITOR'S NOTE: In Fig. 3, x_2 and x_1 are lower case letters as referred to in text.

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (Glass Division). Received January 23, 1934.

[1] F. W. Preston, *Jour. Amer. Ceram. Soc.*, **14** [6], 435 (1931).

The maximum tension is shown as x_1 and the maximum compression as x_2. If the distribution be substantially parabolic, which is the case for good commercial annealing, $x_2 = 2x_1$, there is twice as severe a compression at the edge as there is tension at the center. The actual amount of bow depends on the rate of cooling in the annealing range. The slower the cooling, the flatter the bow.

If at the "strain point" the difference in temperature between the center (of the thickness) of the glass and its surfaces is θ degrees, the stress $(x_1 + x_2)$ at the finish will be $E\alpha\bar{\theta}$ pounds per square inch, where E is Young's modulus (10,000,000 lb. per sq. in.) and, α, the coefficient of expansion for the kind of degrees (Fahrenheit or Centigrade) in which $\bar{\theta}$ is measured. For ordinary wire glass $\alpha = 50 \times 10^{-7}$ if $\bar{\theta}$ is in Fahrenheit degrees or 90×10^{-7} for Centigrade degrees.

Using Fahrenheit degrees for $\bar{\theta}$, $E\alpha = 50$, or for Centigrade degrees $E\alpha = 90$. This combination $E\alpha$ occurs so frequently in calculations of this sort that it is worth while to remember its numerical value.

We are interested, however, in the wave-lengths of displacement, because this is the way it is observed in the polariscope in the first instance. We find it amounts to about 0.3λ, and this corresponds to a stress $f = E\alpha\bar{\theta}$, of 195 pounds per square inch. Since $E\alpha = 50$, $\bar{\theta}$ was about 4.0°F when the glass was cooling through the annealing range; that is, the surface of the glass was roughly 4°F cooler than the middle layers.

Referring to Fig. 3, $x_1 = 0.10\lambda$, $x_2 = 0.20\lambda$ (approximately).

If this stress were superposed on the stress due to the wire and the wire were central, we should get the conditions of Fig. 4. With the wire eccentric to the extent found in practice, the curve would be as in Fig. 5.

In either case the glass appears wholly in compression; there is no part, seen edgewise, that is in tension. This apparently unbalanced and impossible state of affairs is explained by the fact of the wire being in tension.

Comparison with the Experiment

The calculation has been made on the assumption, derived from the earlier paper[1] referred to, that the general compression due to the wire averages 250 pounds per square inch.

In the specimens so far examined in connection with the present investigation, the stress is apparently less. The maximum compression at the edge is rarely more than 0.7λ or possibly 0.8λ, instead of the 0.96λ calculated above.

The appearance of the actual specimens is consistent with a general compression of approximately 150 pounds per square inch, corresponding to about 0.23λ displacement, to a position of the wire a trifle more eccentric than used for the calculation above and to a degree of annealing fairly close to that assumed above. A typical distribution is that shown in Fig. 6.

Mathematical Postscript

Calculation of Stresses Due to Eccentric Wire

The conditions are those more often known as the eccentrically loaded strut.

Let the wire exert a force of P pounds for every b inches breadth of the glass (perpendicular to the paper). Let the glass be d inches thick and the wire e inches off center.

Then the glass is subjected to a combined thrust (compression) P, and bending moment, Pe.

The first is resisted by an area of glass, $A = bd$; the second is resisted by a section modulus, $Z = bd^2/6$, or moment of inertia, $bd^3/12$.

The (compressive) stress at any level, y, from the center of the specimen, counting y positive if it is on the same side of the center line as the wire, is

$$f = \frac{P}{A} + \frac{M}{I}y = \frac{P}{bd} + \frac{12Pye}{bd^3} \qquad (1)$$

It is sufficient for most purposes to know the stress at the two faces, putting $y = \pm d/2$.

$$\text{Then } f = \frac{P}{bd}\left(1 \pm \frac{6e}{d}\right)$$

The + sign refers to the rough face (the side near the wire) and the − sign, to the smooth side. If e is greater than $d/6$, the thrust due to the wire develops tension in the glass near the smooth face.

Having found the stresses at the faces, a straight line plotted between the two gives the stress at any other level. The annealing stresses are then, of course, to be added to these values.

BUTLER, PENNSYLVANIA

ELECTRICAL LUBRICATION OF HAND-MOLDED REFRACTORY SHAPES*

By J. Otis Everhart

ABSTRACT

It is possible to release hand-molded shapes from metal molds by use of direct current without the use of oil, sand, or grog on the interior of the mold. A discussion of the principles involved is presented with observations made while conducting practical tests in an Ohio refractories plant.

I. Introduction

During the past two years electrically lubricated dies for stiff-mud brick machines have been developed and used successfully. They have shown about the same efficiency as oil- and steam-lubricated dies in reducing power consumption and improving the column mechanically and do not have some of the objectionable faults of both.

It was thought that the principle might be used successfully for releasing hand-molded refractory shapes from the mold. A certain amount of experimental work has been done in both the laboratory and plant in developing the process.[1]

II. Principle of Electro-Lubrication

The fundamental principle of electro-lubrication is not new. It is believed that it depends on the action of cataphoresis (migration of particles in suspension to the positive electrode when subjected to an electrical potential) and endosmosis (travel of the liquid through a porous medium to the negative electrode when subjected to an electrical potential). These actions have long been known to physical chemists and are used to dewater clay slips and in numerous industries other than the ceramic.[2]

When the body is comparatively low in water content and more or less rigid as in a stiff-mud body, endosmosis is probably most active in accomplishing the lubricational effect, the clay body acting as a porous medium for the travel of the water to the negative electrode. This would be especially true when electrolytes are present.

In slips or clay suspensions where the moisture content is sufficiently great the particles are at liberty to move through the liquid medium, and cataphoresis is the greater factor in concentrating moisture at the negative electrode.

In a soft-mud body occupying a position midway between those of stiff-mud bodies and slips, both cataphoresis and endosmosis are probably active to a certain extent depending on the moisture content, nature of the clay body, and soluble salts present.

III. Metal Mold Linings

To use this method of lubrication, it is necessary that the mold linings be of metal. They are wired in such a way that an electrical current may be passed from a suitable positive electrode to the portion of the mold where lubrication is desired. This current must be of the direct type. Alternating current can not be used because of its directional change, since any concentration of moisture at the mold surface is destroyed by the immediate reversal of the direction of flow.

First tests were made on molds which had been wired so that both bottom and side walls were negative. A positive electrode of suitable shape was placed on the top after it had been struck off. Current was allowed to pass through the body while the next mold was being filled. In this way production was maintained without interruption. Some difficulty was encountered in securing release of the bottom because the moisture concentrated there acted as a seal preventing penetration of air for release. Accordingly, molds were constructed with wood bottoms and aluminum side walls. These released the shape easily. It seems probable that the ideal mold for this type of lubrication is one that has metal sides and bottom with the bottom insulated from the side walls. The bottom would be used as a positive electrode and the side walls as the negative. The drying action at the positive electrode would sever the bond between body and mold bottom while the concentration of moisture on the side walls would facilitate slippage there.

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (Refractories Division). Received February 15, 1934.

[1] The Fate-Root-Heath Company of Plymouth, Ohio, has developed an electrically lubricated stiff-mud die which has been successfully used. The writer wishes to thank this company for furnishing equipment and much helpful advice and the Aetna Fire Brick Company of Oak Hill, Ohio, for the use of their plant and equipment in conducting some of the tests.

[2] See "Electrical Lubrication of Stiff-Mud Dies," by J. O. Everhart (*Jour. Amer. Ceram. Soc.*, **17**, [9], 272–79 (1934)) for a more detailed discussion.

It is possible to release ware from deep molds without bumping. In fact, if the voltage is too high or the time during which current is applied is too long the ware may fall from the mold before it is completely turned over.

Each mold is wired with a socket on the side into which an extension cord is inserted after placing it on the hot floor. Direct current is applied while the next shape is being molded. When the second shape is finished it is carried to the hot floor and the extension cord connected to it. The first shape is then released and the mold is ready for use again.

IV. Source of Current

A motor-generator set or other means of providing direct current should be used, equipped with a rheostat so that the applied voltage may be regulated as desired. The maximum permissible voltage is probably not over 200; more voltage causes too rapid moisture readjustment with consequent body strains. The rheostat may be adjusted so that the proper amount of moisture is secured. Thick ware will usually require a higher voltage over a given period of time for proper lubrication than will thinner ware.

V. Effect of Salts in Solution

The rate of moisture concentration at the negative electrode is influenced by soluble salts or electrolytes in the body. Nearly all the salts present in clay bodies will increase the electrical conductivity and rate of moisture transfer.[3]

Application of the principle may be made not only to refractory shapes but also to the molding of soft-mud building brick and roofing tile.

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Errata*

Page	Line	Error	Correct
34	19 (left)	P	P_m
34	19 (right)	$\frac{\sigma\theta}{\sigma t} = a\left(\frac{\sigma^2\theta}{\sigma r^2} + \frac{1}{r}\frac{\sigma\theta}{\sigma r}\right)$	$\frac{\partial\theta}{\partial t} = a\left(\frac{\partial^2\theta}{\partial r^2} + \frac{1}{r}\frac{\partial\theta}{\partial r}\right)$
34	30 (right)	$\lambda\left(\frac{\sigma\theta}{\sigma r}\right)_R = -H\theta_R$	$\lambda\left(\frac{\partial\theta}{\partial r}\right)_R = -H\theta_R$
34	31 (right)	$\left(\frac{\sigma\theta}{\sigma r}\right)_R = -h\theta_R$	$\left(\frac{\partial\theta}{\partial r}\right)_R = -h\theta_R$
34	34 (right)	$\theta = Ae^{-\alpha n^2 t} \quad J_o(nr)$	$\theta = Ae^{-\alpha n^2 t} \cdot J_o(nr)$
34	36 (right)	$J_o(nr)$	The term $J_o(nr)$ is to be removed.
35	2 (left)	$\left[\frac{\sigma}{\sigma r} J_o(n_k r)\right]_{r=R} =$	$\left[\frac{\partial}{\partial r} J_o(n_k r)\right]_{r=R} =$
36	20 (left)	$\theta_c = \frac{P(1-\sigma)}{E\alpha} \cdot \frac{1}{2hRS_m}$	$\theta_c = \frac{P_m(1-\sigma)}{E\alpha} \cdot \frac{1}{2hRS_m}$
36	42 (left)	$\theta_s = \frac{P(1-\sigma)}{E\alpha} \cdot \frac{1}{F(h,R)}$	$\theta_s = \frac{P_m(1-\sigma)}{E\alpha} \cdot \frac{1}{F(h,R)}$
37	9 from the bottom (left)	$\theta_c = \frac{P(1-\theta)}{E\alpha} \frac{1}{2hR\{(hR)^{-q} - r\}}$	$\theta_c = \frac{P_m(1-\sigma)}{E\alpha} \frac{1}{2hR\{p(hR)^{-q} - r\}}$
37	7 from the bottom (left)	$\theta_c R\left\{(hR)^{-q} - \frac{r}{p}\right\} = \frac{P(1-\sigma)}{2hp\cdot E\alpha}$	$\theta_c R\left\{(hR)^{-q} - \frac{r}{p}\right\} = \frac{P_m(1-\sigma)}{2hp\cdot E\alpha}$

* The following changes should be noted by readers of the *Journal* for February, 1934, in the paper by Kozo Tabata and Taro Moriya "On the Thermal Endurance of Glass."

CERAMIC ABSTRACTS[1]

Compiled by the

AMERICAN CERAMIC SOCIETY

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Vol. 13 **October, 1934** **No. 10**

Abrasives

Diamond-impregnated carboloy. Geo. F. Taylor. *Gen. Elec. Rev.*, **37** [2], 97–99 (1934).—A cemented carbide diamond-impregnated tool has been developed for dressing grinding wheels. Illustrated. R.H.H.P., Jr.

Electrical nature of iron sparks emitted from a grinding wheel. Ukitirô Nakaya. *Sci. Papers Inst. Phys. Chem. Research* [Tokyo], **23** [483], 185–201 (1934).—A study of the path of iron sparks in an electric field and of the number of ions emitted by the sparks leads to the following conclusions: The spark particle is positively charged in the early stages but becomes negative toward the end of its path. When the drop explodes the resulting drop is positively charged. Both positive and negative charges are emitted. The charge emitted is of the order of 10^{-2} e.s.u./cm. in the middle of the track and of 10^{-3} e.s.u./cm. toward the end. In all cases positive ions are more abundant in the middle of the track and negative ions toward the end. A number of curves are given showing the variation of the ratio of charge to mass for the spark along its path. Eighteen photographs of spark tracks are included. J.B.A.

Fine-machining of nonferrous metals. O. Schlippe. *Metallwirtschaft*, **13** [4], 61–67 (1934).—Methods and tools for finest treatment of metals, either to improve surface quality only or to improve surface quality with simultaneous finishing to accurate size within required tolerances, are described in detail. To obtain a high polish for turned surfaces "diamond-steels" as cutting tools are used at a cutting velocity of 170 m./min. at a feed of 0.15 mm./revolution. The life of such cutting tools depends largely on their mounting which should be as free from vibration as possible. Bibliography. M.H.

Metal polishing abrasive must have high capillarity. William Pettigrew. *Metal Cleaning & Finishing*, **6** [7], 375–76 (1934).—Capillarity is one of the principal factors which influence the strength of a polishing wheel head. Illustrated. E.J.V.

Resistance to abrasion in relation to hardness. S. A. Main. *Proc. Inst. Mech. Eng.*, **121**, 523–32 (1931).—The unsatisfactory position of our knowledge of abrasion and of abrasion testing is explained and discussed. Hardness is frequently taken as a measure of resistance to abrasion, but the important property is not the initial hardness of the material, but its hardness after the deformation which it suffers under the particular conditions of abrasion. The remarkable properties of manganese steel in rails are due to its property of work-hardening to a greater extent for a given deformation than other materials and of bearing a greater extension than other steels, but if used for grinding soft materials which do not deform it, manganese steel does not give a markedly higher life ratio than other steels. The diamond pyramid, Herbert pendulum, and scleroscope methods are more suitable for this kind of testing than the normal Brinell test, since they give smaller indentations and enable the acquired hardness near the surface to be measured. There is much need for a study of the mechanism by which the metallic particles are torn away. (*J.I.M.*)

Study of abrasion. Seizo Saito. *Sci. Repts. Tôhoku Imp. Univ.*, **20** [i], 560–73 (1931).—When the nature of contact is rolling with slippage between the contact surfaces, as in the Amsler universal wear-testing machine, a test piece rotating at a higher speed is less worn than one rotating at a lower speed. When two test pieces of different hardness are rotated the abrasion is less if the harder sample rotates more quickly and is greater if the reverse condition holds. When the powder produced by the abrasion is left between the contact surfaces the amount of abrasion is greatly increased, sometimes 100-fold. (*J.I.M.*)

PATENTS

Abrasive. Soc. pour l'ind. chim. à Bâle. Swiss 163,625, Nov. 1, 1933. Granular abrasive material is mixed with an amine resin and molded to a solid body by hot-pressing. Thus, $PhNH_2HCl$ is treated with CH_2O and the product mixed with corundum and hot-pressed. (*C.A.*)

Abrasive carbides. Norton Co. Fr. 758,016, Jan. 9, 1934. An abrasive carbide of Si or B is made by treating a mixture of the oxide and charcoal in an electric resistance furnace, the charge of the furnace being provided with a core of granular material composed, for the greater part, of abrasive carbide, through which the current passes. (*C.A.*)

[1] The bold-face number following the journal is the volume, the issue number is in brackets, followed by the page numbers, then the year in parentheses.

Abrasive sheets. MINNESOTA MINING & MFG. Co. Fr. 756,564, Dec. 12, 1933. Polymerization or condensation products of an aldehyde and an amide or imide are used as bonding agent for abrasives on paper, etc. Fr. 757,775, Jan. 4, 1934. The support is impregnated with a waterproofing composition and coated with a composition containing nitrocellulose, vegetable oil and resin, and a material increasing the friction, *e.g.*, ground SiO_2. Fr. 756,907, Dec. 18, 1933. Polymerization or condensation products of polyhydric alcohols with polybasic acids or phenols are used as bonding agents for abrasives on paper, etc. (*C.A.*)

Abrasives. DEUTSCHE GOLD- UND SILBER-SCHEIDEANSTALT VORM. ROESSLER. Fr. 762,230, April 7, 1934. The abrasive material and a binder are mixed and formed into granules which are then agglomerated so that a cellular structure is obtained. See also *Ceram. Abs.*, **13** [8], 197 (1934). (*C.A.*)

Adjustable disk and tool grinder. A. E. NELSON AND ALBERT HUMPHRIES. U. S. 1,967,447, July 24, 1934.

Buffing tool. FRED RICKS (United Shoe Machinery Corp.). U. S. 1,966,521, July 17, 1934.

Crankshaft grinder. C. H. CRAFT (Wallace Miller). U. S. 1,967,744, July 24, 1934.

Devices for grinding razor blades. H. GUTSCHE AND D. E. A. GUTSCHE. Brit. 413,248, July 18, 1934.

Grinding machine. HANS ERNST AND H. R. ISLER (Cincinnati Grinders, Inc.). U. S. 1,969,063, Aug. 7, 1934.

H. W. MILLER. U. S. 1,967,964, July 24, 1934.

Manufacture of rubber-bonded abrasive articles. R. C. BENNER (Carborundum Co.). U. S. 1,953,983, April 10, 1934, and 1,969,497, Aug. 7, 1934.

Process of preparing grinding or polishing tools. ERNST ELBEL AND OTTO SUSENGUTH (Bakelite Gesellschaft mit beschrankter Haftung). U. S. 1,968,799, July 31, 1934. A process of manufacturing abrasive and polishing implements comprises mixing a solution in a solvent selected from the group of hydrogenated aromatic hydrocarbons, hexahydrogenated phenols and their esters, and hydroaromatic cyclic ketones of a heat-hardenable phenol-aldehyde resin in the resitole state with an abrasive filler, molding the mixture so obtained, and hardening the resin by heating.

Roll grinding machine. R. C. LEWIS AND G. V. HULTGREN (Farrel-Birmingham Co., Inc.). U. S. 1,968,255, July 31, 1934.

Sharpener for meat-slicing machines. W. A. VAN BERKEL (U. S. Slicing Machine Co.). U. S. 1,968,663, July 31, 1934.

Sharpener for slicing machines. W. A. VAN BERKEL (U. S. Slicing Machine Co.). U. S. 1,968,664, July 31, 1934.

Sharpening apparatus. W. A. VAN BERKEL (U. S. Slicing Machine Co.). U. S. 1,968,662, July 31, 1934.

Art and Archeology

Analytic color-tone chart. ROGERS D. RUSK. *Jour. Opt. Soc. Amer.*, **23** [5], 182–83 (1933).—An analytic color-tone chart of triangular arrangement in which white, black, and color are separated by uniform steps is presented for describing mixtures of pigments and combinations of colored illuminants. R.H.H.P.,JR.

Art relics of Roman times in Austria. H. KAUFMANN. *Illus. London News*, **184,** 831 (1934).—An exhibition held in Vienna showed the entire results of Roman excavations in Austria. Illustrated. H.H.S.

Color oxides and methods employed in color matching. THOS. H. MCKEOWN AND GEO. A. LEE. *Jour. Can. Ceram. Soc.*, **3,** 34–37 (1934).—The composition and specific uses of color oxides, opacifiers, and glaze stains are given. Color matching is discussed. J.G.P.

Early Sumerian sculpture. HENRY FRANKFORT. *Illus. London News*, **184,** 774–78 (1934).—Statues 5000 years old found at Tell Asmer have caused a stir among archeologists. Illustrations in color. H.H.S.

Fish motifs on ancient pottery. S. W. FROST. *Sci. Monthly*, **38,** 534–78 (1934).—Many beautiful fish patterns have been found on pottery from the earliest times. Illustrated. H.H.S.

Fusible colors for the decoration of glass. FAUSTO POZZI. *Corriere Ceram.*, **14** [6], 211–19 (1933).—The historical development of the use of fusible colors in glass decoration is discussed briefly; compositions and methods of preparation of antique colors are given. A fusion furnace capable of melting about 50 kg. in 8 hr. and a ball mill used in grinding the colors are described. Using eight frits, P. prepared twenty-five colors, ranging throughout the spectrum, some opaque and some transparent. Their compositions and colors are listed, and their coefficients of expansion and of elasticity briefly discussed. Illustrated. H.F.V.

Neutral value scales. I. Munsell neutral value scale. A. E. O. MUNSELL, L. L. SLOAN, AND I. H. GODLOVE. *Jour. Opt. Soc. Amer.*, **23** [11], 394–411 (1933).—The Munsell standard value scale, intermediate between the former logarithmic and the exponential scales is defined for use on standard color charts. The methods of just-noticeable difference and of equal-sense difference used in evaluating the scale are described. Value scales determined by a number of observers using the two methods are in excellent agreement. R.H.H.P.,JR.

Saturation scale for yellow colors. DEANE B. JUDD. *Jour. Opt. Soc. Amer.*, **23** [2], 35–40 (1933).—The relationship between colorimetric purity of the stimulus and saturation of the color evoked under specified observing conditions has been determined for yellow colors by using the yellow series of Lovibond glasses. The integral of the sensibility to purity change from zero purity was taken as the saturation of the yellow color. The saturation purity curve is compared with previous data, and it is concluded that an empirical relation yields a saturation scale for yellow which is close to the true one. R.H.H.P.,JR.

Study of the technique of stained glass of the Middle Ages. G. CHESNEAU. *Bull. soc. encour. ind. nat.*, **132,** 609–25 (1933).—Stained glasses of the 12th and 13th Century cathedrals were examined. The raw materials used for the fundamental white glass were sand, plant

ashes to furnish K, common salt, and a little MnO to neutralize the coloration due to Fe oxides. The glass was worked on a table and varied in thickness. Some glass was blown in cylinders and had uniform thickness. Glass was colored by the addition of metallic oxides. Cu_2O gave red glass; CoO with traces of CuO gave blue glass; the blue was often modified by the presence of NiO or MnO; yellow was produced by the oxysulfide of Sb with some Fe_2O_3; violet was produced from pyrolusite which contained some Fe; CuO was added to give green. All of these metallic oxides with the exception of Co were found in France. The Pb used to secure the glass in the windows contained some Sb, making it slightly harder. (*C.A.*)

PATENTS

Coating porcelain, glass, etc., with platinum. ARTHUR BAHRDT. Ger. 595,356, April 9, 1934. Use is made of complex compounds of Pt with alkyl halides or their derivatives, other than derivatives containing S. $PtMe_3Cl$ is the preferred compound. The Pt compound is applied to the material, and the latter is then warmed to 150 to 180° and finally heated in a muffle furnace. (*C.A.*)

Coating surfaces of vitreous or vitrified bodies with metals, alloys, or metallic compounds. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY, ET CIREY. Brit. 413,900, Aug. 1, 1934.

Colored photographic image and method of producing. H. D. MURRAY AND D. A. SPENCER (Colour Photographs, Ltd.). U. S. 1,968,956, Aug. 7, 1934.

Color photography. E. A. WEAVER (Technicolor, Inc.). U. S. 1,968,112, July 31, 1934.

Designs for:

Bottle. WILLIAM GUYER (Joseph E. Seagram & Sons, Inc.). U. S. 92,901, July 31, 1934. A. C. MEYER. U. S. 92,821, July 17, 1934. T. J. PIAZZOLI (Capstan Glass Co.). U. S. 92,975, Aug. 7, 1934. N. F. STEUER (Owens-Illinois Glass Co.). U. S. 92,828, July 17, 1934, and 92,985, Aug. 7, 1934.

Plate. B. N. KANE (Decal Products Co.). U. S. 92,807 and 92,808, July 17, 1934. GEORGE KOLB. U. S. 92,849, July 24, 1934.

Saucepan. W. T. CHRISTMAN (Federal Enameling & Stamping Co.). U. S. 92,880, July 31, 1934.

Solid fuel range. G. E. PICKUP (Wehrle Co.). U. S 92,823 and 92,824, July 17, 1934.

Method of producing color photographic images by development. M. W. SEYMOUR (Eastman Kodak Co.). U. S. 1,969,479, Aug. 7, 1934.

Ornamenting pottery. HANS GRIESBACH. Ger. 594,-151, March 13, 1934. A thin noble-metal coating and a layer of glass are applied in turn to unglazed pottery with the aid of fluxes. (*C.A.*)

Photographic color process. L. D. MANNES AND LEOPOLD GODOWSKY, JR. U. S. 1,969,469, Aug. 7, 1934.

Photographic material for the production of color photographs. B. GASPAR. Brit. 412,950, July 18, 1934.

Three-color photography. GERD HEYMER (Agfa Ansco Corp.). U. S. 1,968,944, Aug. 7, 1934.

Cements

Hydrolytic decomposition of tricalcium silicate. B. TAVASCI. *Ann. chim. applicata*, **23**, 413 (1933).—In the system CaO–SiO_2–H_2O at ordinary temperature and pressure, the solid phase in equilibrium with crystalline $Ca(OH)_2$ and liquid has the composition $5CaO,3SiO_2$, aq., so that the hydrolysis of Ca_3 silicate may be expressed by $3(3CaO,SiO_2) + aq. = 5CaO,3SiO_2$ aq. $+ 4Ca(OH)_2$. The hydrosilicate formed resembles zeolite in its behavior. When the solid $Ca(OH)_2$ disappears, the concentration of CaO in the liquid falls rapidly to values below that corresponding to the decomposition of Ca_2 aluminate. When this condition is established, pozzuolana and slag cements should have greater chemical stability than fused cement. (*T.C.S.E.*)

BULLETIN

Calcium aluminate hydrates and their double salts. C. R. W. MYLIUS. *Acta Acad. Aboensis. Math. et Phys.*, **7**, No. 3, 147 pp. (1933); *Bldg. Sci. Abs.*, **6**, 124 (1933).—This investigation was undertaken to discover whether the retardation of setting of cement caused by gypsum is connected with the formation of the Ca-sulfoaluminate compound and whether corresponding compounds of other Ca salts can be produced. A series of di-, tri-, and tetra-Ca aluminate hydrates obtained is tabulated, and double salts with Ca chloride, nitrate, bromide, iodide, chlorate, iodate, and acetate are described. These compounds are highly unstable and are produced only in solutions of definite concentration. On account of their slight solubility and marked instability, optical examination of the crystals provides the only practicable method of analysis. Tabulated results of such examinations are given. The Ca salts that retard setting form sparingly soluble compounds which crystallize well. The constitution of the aluminates is discussed. A table of analyses and dehydration curves for the isolated substances and a bibliography are included. (*C.A.*)

PATENT

Cementitious material of the high alumina type. N. V. S. KNIBBS. U. S. 1,966,864, July 17, 1934. The process of producing hydraulic cements of the high alumina type from bauxite and other materials consisting essentially of free alumina comprises subjecting a mixture of such material and lime to the action of steam under a pressure greater than atmospheric pressure whereby hydrated calcium aluminates are formed, subjecting the product thus obtained to heat treatment at a temperature sufficient to drive off the combined water and to the action of carbon dioxide until any free lime present and substantially one-third of the lime in combination with alumina are converted into calcium carbonate.

Enamels

American porcelain enamel plant layout has duplicate in England. F. G. JAEGER. *Better Enameling*, **5** [7], 10–11 (1934).—The Luton, England, plant of "Electrolux, Ltd.," is a duplicate of the Evansville, Ind., plant of Servel, Inc.; sketches and photos of the latter plant and its equipment were used in designing the English plant. German-made mills, constructed so they can be taken apart for relining by the removal of a few bolts, and other equipment in various departments are described. Illustrated. E.J.V.

Cleaning metal surfaces before finishing. C. F. SCRIBNER. *Ind. Finishing*, **10** [8], 12–14 (1934).—Old varnish can be removed by burning off at 650 to 700°F. Rust can be removed by sandblasting. Thin rust coatings can be removed by kerosene or gasoline or by pickling in dilute sulfuric acid. A 20% solution of sodium citrate in water, a 10% solution of ferrous sulfate and water, or a 3½% solution of boric acid may also be used. A concentrated solution of acid will not remove rust. Parts must be dipped in a neutralizing bath as soon as removed from acid. Acid or soda baths can not safely be used on aluminum or on white metal alloy die castings. Suitable solutions for removing lubricants used in blanking, stamping, drawing, and spinning are available. Illustrated. J.L.G.

Construction methods for porcelain enameled buildings. H. D. CHASE AND E. W. GOETZ. *Better Enameling*, **5** [7], 4–7 (1934).—The following methods of porcelain enamel building construction are described: White Castle, Wheeling, Revocon, Stewart-Vitrosteel, Steelox, "Clip-Strip," Moore and Toussaint, Stran-Steel, and Glasiron Macotta. Glasiron roofing and wall tile, Veos tile, Porcelite wall tile, and cast-iron wall tile are also described. Illustrated. E.J.V.

Development of a continuous vitreous enameling furnace. III. FREDERICK S. MARKERT. *Enamelist*, **11** [10], 12–15 (1934).—After installation of the initial U-type furnace, thirty-one were built in a period of four years. Progressive improvements were embodied in the new furnaces, the improvements and correction of faults being a matter of furnace construction details and materials placement. The combustion chamber was changed from a twin-arch type to one similar to those on successful box-type furnaces, and a cross-firing principle was adopted. The thickness of the main firebrick side walls was increased to have them act as a heat reservoir. A thin section super-refractory tile was developed for the muffle side walls. Improvements made in the firing chamber rear wall, roof, firing chamber proper, the preheating and cooling zones, and the stack are also described. For Part II see *Ceram. Abs.*, **13** [9], 231 (1934). E.J.V.

Electrolytes in the enamel industry. ANON. *Glashütte*, **64** [6], 85–87 (1934).—The action of electrolytes in an enamel slip is discussed. Electrolytes used at present are those having (1) a weak effect and (2) a strong effect. Borax, sal ammoniac (ammonium chloride), soda, potash, and common salt belong to the first group; fired magnesia, Epsom salt (magnesium sulfate), magnesium chloride, hydrochloric acid, and Glauber salt belong to the second group. The use of these electrolytes is discussed. Sal ammoniac is considered to be a harmless electrolyte although the hydrogen chloride set free may react with some of the enamel bases and affect the enamel surface. Borax is extensively used, especially for ground enamels. Another harmless electrolyte with an intensive effect is magnesia; it absorbs carbonic gas from the air, however, forming magnesium carbonate. The latter gives up carbonic gas with difficulty and only at high temperature (formation of blisters). Epsom salt is also used but is dangerous because it may be decomposed into magnesia and sulfuric acid by the temperature, and the enamel is affected by it. This is especially true of colored enamels. Soda and potash produce in many cases a dulling of the enamel or efflorescences on its surface. A new electrolyte, a "magnesium oxydorate" compound, called Electrolyte US has been developed. Experiments with it showed its complete harmlessness. M.V.K.

Enameler wins success. ARCHIE BELL. *Enamelist*, **11** [10], 22 (1934).—A brief biographical sketch of H. Edward Winter, the young artist known for his porcelain enamel murals, decorative panels, tables, trays, and other pieces, is presented. Illustrated. E.J.V.

Experiments in producing colored and shield enamels of high quality. ANON. *Glashütte*, **64** [9], 152–53 (1934).—Experiments dealing with the improvement of the intensity of color and luster of enamels are described. It was found that the composition of the enamel and the pigments have a great effect on the appearance and color of the enamel. Raw materials containing fluorine must be avoided; cryolite is not suitable. Sodium fluosilicate and $BaCO_3$ are suitable materials. An enamel of high quality is analyzed. Instead of clay, Ultra-Sil, a silicate poor in alumina, is recommended. A table showing the differences in color and appearance of the same enamel with Ultra-Sil or 4% clay is given. M.V.K.

Explanation of the adhering problem in sheet iron enamels. A. DIETZEL. *Emailwaren-Ind.*, **11** [19], 161–66 (1934); abstracted in *Verre & Silicates Ind.*, **5** [11], 213–14 (1934).—The process of enameling without adhering oxides is reviewed: a rapid formation of hammer scale at the beginning of firing, consisting of a mixture of FeO and Fe_3O_4, and a dissolving of ferrous salts in the enamel, which becomes green during firing, take place. This enamel does not adhere. By lengthening the firing, a black enamel adhering well and containing crystals of magnetite (Fe_3O_4) is obtained. An excessive firing produces a reddish enamel (Fe_2O_3) which is burned. The special oxides designated to promote adherence may be divided into three groups: (1) Those producing precipitates, such as ferrous chromates and ferrous vanadates. They are technically insufficient to produce adherence. (2) Oxidation agents, such as nitrates, nitrites, manganese dioxide. These materials alone do not insure adherence although they promote the formation of magnetite. (3) Cobalt and nickel oxides whose effect was especially studied. The reactions occurring are (I) Fe + CoO (NiO) $\longrightarrow$ FeO + Co (Ni); (II) 2FeO + CoO (NiO) $\longrightarrow$ Fe_2O_3 + Co (Ni). The metallic Co or Ni is precipitated after reaction (I) and forms, with the iron and the enamel, local currents and short circuits which greatly corrode the

iron surface. The enamel is deposited and adheres in these cavities. The precipitation of Co by Fe and the corrosion of the sheet iron is possible only because Co is a noble metal in comparison with Fe, *i.e.*, it has less affinity with oxygen. The large proportion of Co increases the adherence of the enamel contrary to general opinion. M.V.K.

"Luminous" buildings of porcelain enamel. W. H. ADAMS & ASSOCIATES. *Enamelist*, **11** [10], 28–29 (1934).—Light itself becomes an architectural element in the new "Luminous" buildings designed by W. H. Adams & Associates, of Cleveland, Ohio. Glass, which transmits light, and porcelain enamel, which reflects light, are the logical and natural materials for this type of building, and the builders plan to make generous use of porcelain enamel. Illustrated. E.J.V.

Making cookers at Rugby. BRITISH THOMSON-HOUSTON CO., LTD. *Elec. Rev.*, **115** [2955], 41–42 (1934).—The vitreous enameling of electric cookers at the Rugby plant and the construction of the Torribar heating element for the cooker are described in detail. Parts are dried in a drier 50 x 12 ft. with inspection windows and an overhead crane operated from outside. The enamel is either sprayed on or applied by dipping or "slushing." Mottling is secured by low-pressure spraying over dipped coats. The enamel is dried on conveyers passing through drying ovens heated to 100°F at the entering end and 180°F at the exit end. Firing temperatures are 860°C for ground coat for 5 min. and 830°C for white coat. Electric furnaces are used. The Torribar heating element uses powdered magnesium oxide as an electrical insulator around the spiral heating element which is encased in a nickel tube. Illustrated. See also *Ceram. Abs.*, **13** [4], 83 (1934). J.L.G.

Management methods for enamel plant cost control. III. Incentives. ROY E. DYBVIG. *Better Enameling*, **5** [7], 14–18 (1934).—The nature of the enameling process determines to a great extent the type of incentive plan to adopt. In the average industry the workmanship of each operator is independent, but in an enamel plant, poor workmanship on the part of a pickler, a dipper, a burner, or a sprayer will cause rework affecting the entire plant. Coöperative effort toward maintaining a standard of quality is therefore one of the first requirements. Under a group bonus plan every operator is checking and inspecting the workmanship on previous operations for the mutual benefit of the group. A larger individual production may be had through an individual incentive plan but this in itself is secondary to high-quality workmanship. For Part II see *Ceram. Abs.*, **13** [9], 231 (1934). E.J.V.

Metallic diffusion into iron in the solid state from sprayed coatings. PETER BARDENHEUER AND RICHARD MÜLLER. *Mitt. Kaiser Wilhelm Inst. Eisenforsch. Düsseldorf*, **14** [20], 295–305 (1932).—The cementation of iron was investigated with different metals and alloys in the form of powder of Ni, Cr, mixtures of Cr and Ni, Cr and Al, Ni and Al, Ni and Si, and alloys of Cr and Si, Cr and Ni, Ni and Al, and Cr and Al. Ni diffuses badly and Cr, well. Mixtures of Cr and Ni, as well as Ni and Si gave good results. Al diffuses quickly, although to small contents, but retards the diffusion of other metals. Alloys and mixtures behaved alike. Oxides which enter the coating during spraying slow up the diffusion. This is particularly noticeable in comparing Cr and Ni because of their different affinity for oxygen. It is concluded that in the diffusion of metals in the solid state the gaseous phase is also of importance. J.B.A.

Modern porcelain enamel laboratories. FERRO ENAMEL CORPORATION. *Enamelist*, **11** [10], 18–21 (1934).—Outstanding features incorporated in the new laboratories at the Ferro Enamel Corp. plant and equipment installed in various sections of the chemical and enameling laboratories are described. Illustrated. E.J.V.

More accurate control of color matching. C. P. SCRIPTURE. *Ceram. Ind.*, **23** [2], 94–96 (1934). E.J.V.

Porcelain enamel brings new appeal to cast-iron kitchenware. J. A. DECELLE. *Ceram. Ind.*, **23** [2], 69–70 (1934).—The Chicago Hardware Foundry Co. has developed new enamels which withstand all the usual tests applied to kitchenware. They contain no antimony, barium, zinc, or lead, and a special process is used in preparation. The ware is given a cover coat developed for this ware and a special ground coat. Illustrated. E.J.V.

Porcelain enamel in the modern bakery. ANON. *Better Enameling*, **5** [7], 13 (1934).—The 61- x 14-ft. oven in the Salerno-Megowen Biscuit Co. bakery in Chicago is described. The oven has 1300 sq. ft. of white porcelain enamel surface and is of insulated steel construction. Illustrated. E.J.V.

Progress in enameling kilns and refractory materials in U. S. ANON. *Email.*, **1** [8], 7–20 (1933); abstracted in *Emailwaren-Ind.*, **11** [18], 159 (1934).—The development of refractory materials and of the firing technique leads to a great improvement in the building of enameling kilns. M.V.K.

Progress in the manufacture and use of enamel. L. VIELHABER. *Chem.-Ztg.*, **58** [53], 444–45 (1934).—A brief review of changes made in the composition of enamel batches to adapt them to various kinds of ware is given. M.V.K.

Reboiling. F. R. PORTER. *Jour. Can. Ceram. Soc.*, **3**, 43–44 (1934).—Reboiling is discussed, and the pertinent results of researches on this problem are given. See also *Ceram. Abs.*, **12** [8], 292 (1933). J.G.P.

Revocon system. ARCHITECTURAL METALS CORPORATION. *Enamelist*, **11** [10], 9–11 (1934).—Illustrated E.J.V.

Sheet steel. W. H. SHIPMAN. *Jour. Can. Ceram. Soc.*, **3**, 37–39 (1934).—A brief résumé of the manufacture of sheet steel is given. J.G.P.

Vitreous enamel in electrotechnics. B. M. TAREEV. *Keram. i Steklo*, **10** [5], 22–24 (1934).—The electric properties and advantages of using vitreous enamels in electrotechnics and their production in U.S.S.R. are dealt with. M.V.K.

PATENTS

Enameled gold-alloy or platinum tooth crowns. REZSŐ HEJCMANN. Hung. 106,893, Aug. 1, 1933. A mixture of SiO_2 615, borax 2.0, crystalline soda 1.65, $NaNO_3$ 0.30, cryolite 1.20, and SnO 0.50% is heated for 2 hr. to 1000°

and powdered, and 10 parts of the powder are mixed with 0.5 part white clay and an opacifier; the mixture is colored with the usual metal oxides and, after addition of about 0.75 liter water per kg., ground in a mill for 24 hr. An aqueous or turpentine pulp made from the dust is applied to the metal crowns and fired. (*C.A.*)

Enameling. O. HOMMEL Co. Ger. 590,651, Jan. 8, 1934. TiO_2 enamels are described. (*C.A.*)

Enameling iron. IGNAZ KREIDL. Austrian 136,003, Dec. 27, 1933. The adhesion of the enamel is promoted by alloying the Fe with a small proportion of suitable metal, particularly Ni or Co. (*C.A.*)

Glass

Adjusting firing in tank furnaces. FRITZ ALTHOF. *Glashütte*, **64** [1], 5–7; [2], 19–21 (1934).—The effect of defective regulation of firing on the quality of glass is discussed. Cases from practice are given. M.V.K.

Adsorption of helium on glass at liquid-helium temperatures. W. H. KEESOM AND G. SCHMIDT. *Proc. Acad. Sci. Amsterdam*, **36**, 832–35 (1933).—The adsorption of He on glass between 1.13 and 3.56°K is given by the equation, $q^4 = p/[0.26\ (p_s - p) + p]$, in which q is the fraction of wall covered (for a monomolecular layer), p is the pressure, and p_s the saturated vapor pressure. (*C.A.*)

Adsorption of neon on glass at liquid-hydrogen temperatures. W. H. KEESOM AND G. SCHMIDT. *Proc. Acad. Sci. Amsterdam*, **36**, 825–32 (1933).—Between 14.45 and 20.28°K, the adsorption of Ne on glass is given by the equation, $q^3 = p/[0.7\ (p_s - p) + p]$, in which q is the fraction of wall covered (for a monomolecular layer), p is the pressure, and p_s the saturated vapor pressure. (*C.A.*)

Apparatus for controlling streaks in Fourcault glass. A. LOGVINENKO. *Keram. i Steklo*, **10** [4], 15–17 (1934).—A simple apparatus for controlling streaks in glass produced in Fourcault machines is described. The basic part of the apparatus consists of a "linear source of light," *viz.*, an electric bulb with one tungsten filament. Details are given. Illustrated. M.V.K.

Barium in ancient glass. H. C. BECK AND C. G. SELIGMAN. *Nature*, **133** [3374], 982 (1934).—Blue Chinese beads dated about the second half of the 3rd Century B.C. (Han Chun beads) were found to have high specific gravities (about 3.5). A chemical analysis shows the following constituents: SiO_2 41.9, PbO 24.5, BaO 19.2, CaO 4.5, $Fe_2O_3 + Al_2O_3$ 4.4, alkalis 4.5%, and CuO trace. Barium glass was first made in modern times about 1884 at Jena. No record of any ancient glass containing barium is known to the authors. Not all Chinese glass of high specific gravity nor all Han glazes contain barium. Illustrated. J.L.G.

Chemical durability of containers. A. K. LYLE. *Glass Ind.*, **15** [7], 147–48 (1934).—Investigations conducted to determine possible effects on foods of alkalis derived from the glass container are summarized. Practical service tests and researches on food in contact with glass demonstrate definitely that the slight solubility of glass in fruit and vegetable juices presents no great problem in chemical durability. Accelerated tests for determining chemical durability by the autoclave or the powder method are of little value for successful food packing but may be used by glass manufacturers to advantage to control quality or to determine the results of composition changes. See also *Ceram. Abs.*, **12** [12], 416 (1933). E.J.V.

Design of a muffle "glory hole." H. W. ALLAN. *Gas World*, **100**, No. 2594; *Ind. Gas Suppl.*, **6**, 33–34 (1934).—A gas-fired experimental recuperative furnace for reheating glass has resulted in a fuel saving and improvements in gas quality. (*C.A.*)

Development of the photographic objective. R. KINGSLAKE. *Jour. Opt. Soc. Amer.*, **24** [3], 73–84 (1934).—K. follows the development of photographic lenses from 1812 to the present day stressing the reasons which led designers to adopt various types. A glimpse is given of the future trend in lens design. R.H.H.P., JR.

Development of a reliable method for determining solubility of soda-lime glasses. O. G. BURCH. *Bull. Amer. Ceram. Soc.*, **13** [8], 200–204 (1934).

Dulling of white enamel containing antimony. LANG. *Glashütte*, **64** [8], 121–23 (1934).—The dulling of white enamel containing antimony or its compounds is characteristic. The enamel loses its luster in spots, due to the presence of antimony. The following points must be observed when using antimony in the batch: (1) The least possible amount of materials containing alumina should be employed; feldspar is dangerous to the luster effect. Cryolite is harmful when used with antimony, while practice shows that sodium fluosilicate behaves well. (2) Antimony enamels require longer grinding. (3) Not more than 5 to 6% clay can be added to the mill. (4) Antimony enamels should not be stored for a long time. (5) The enamel should not be ground too fine. (6) Only one kind of opacifier should be added to the mill. (7) White antimony enamels are sensitive to the firing atmosphere and temperature. M.V.K.

Education and research in glass technology. W. E. S. TURNER. *Glass Ind.*, **15** [7], 156–58 (1934).—T. sketches the main lines of progress in the provision of facilities for instruction and research in glass technology in the various institutions in the world, briefly discussing each institution and its particular features of interest. E.J.V.

Effect of composition of glass and temperature and strength of alkali solutions on bottle scratching, with discussion of methods proposed to measure scratchability. H. A. TREBLER AND J. H. SHRADER. *Proc. Intern. Assn. Milk Dealers, Plant Sect., 26th Ann. Convention*, pp. 60–68 (Sept., 1933).—There is no evidence that the cleaning solution now used in bottle washers (0.3 to 3% alkalinity for 8 to 16 min. at 140 to 160°F) materially contributes to a softening of the glass surface, making it more susceptible to scratching. At present no practical laboratory test for resistance to scratching is known. Bottles should be bought on the basis of service test both for breakage and scratching. (*C.A.*)

Electrically fired furnaces in the glass industry and

their economy. J. HOROWITZ. *Glashütte*, **64** [5], 67–71; [6], 83–85; [7], 101–102; [13], 215–19; [15], 245–47; [19], 305–306; [21], 327–30; [24], 401–403; [25], 415–17 (1934).—A brief review of difficulties encountered when melting glass in electric furnaces is given. The working principles of electric-arc and resistance furnaces are discussed in detail. The characteristics, operation, economy, and other data of different electric glassmelting furnaces are dealt with. Illustrated. Partially translated in *Glass Ind.*, **15** [4], 62–63; [6], 129–30; [7], 159–60 (1934).

M.V.K.

Essentials of glass technology based on American practice. XI. S. R. SCHOLES. *Ceram. Ind.*, **23** [2], 89–92 (1934).—The prime essential of glass composition is that the mixture of oxides shall contain a preponderance of one of the oxides which by itself is a persistent glass-former. These are all "acid" in character. The prerequisites of glasses are considerations of economy, fusibility, workability, durability, and stability. Each of these is influenced by some constituent in the batch composition. Extensive quotation on the definition of glass, the binary system Na_2O-SiO_2–SiO_2, the ternary system Na_2O-SiO_2–CaO-SiO_2–SiO_2, and crystallization paths from the published work of G. W. Morey (*Ceram. Abs.*, **12** [10–11], 360 (1933)) is included in the discussion. Illustrated. For Part X see *ibid.*, **13** [9], 233 (1934).

E.J.V.

Expansion characteristics of common glasses and metals. E. E. BURGER. *Gen. Elec. Rev.*, **37** [2], 93–96 (1934).—To determine their sealing possibilities, the expansion characteristics of some common glasses and metals were investigated by a differential elongation method in an apparatus originally designed to study the creep in steel at elevated temperatures. Curves show that by adjusting the compositions of the glasses and metals, their expansions can be made to match closely. Illustrated. R.H.H.P., JR.

Fields of application of rare earths. KARL QUASEBART. *Chem.-Ztg.*, **58** [36], 365–67 (1934).—Cerium is used in glass as a decolorizer or colorizer. The decoloration effect of cerium and especially its mixture with other rare earths is based on the fact that it converts the iron present in glass into the 3-valence form, which has much less coloring power, producing a very strong decoloration. The presence of arsenic destroys the decolorizing power of cerium, and therefore the glass should be refined with saltpeter, Glauber salt, or common salt (when using the latter, the evaporating sodium chloride may attack the heated parts of the furnace). The usual mixture of nickel and selenium or cobalt and selenite of soda or zinc can be used for the complementary physical decolorizing, depending on the refining method; 0.2% cerium preparation (calculated from the amount of sand) is sufficient to produce decoloration. The decolorizing action of cerium is chemical, while that of neodymium is physical. The physical decoloration is discussed in detail. The usual coloring agents lower the light permeability and index of refraction of glasses, while the use of neodymium and praseodymium does not affect them. Pure neodymium yields a changing color tone between red and lilac, and praseodymium, a color tone between green and yellow. Coloring crystal glasses with neodymium and praseodymium resulted in artificial precious stones which are superior to some natural precious stones. Neophane glass, a neodymium glass, is ideal for spectacle glass. The properties of thorium and its use as crucible material are discussed. M.V.K.

Fuel oil firing of glass-tank furnaces. ALEXANDER NADEL. *Glashütte*, **64** [9], 145–50 (1934); abstracted in *Keram. i Steklo*, **10** [5], 33–34 (1934).—Various types of oil burners and the properties of fuel oil and its composition and combustion are discussed. The operation of fuel-oil furnaces and their advantages are described.

M.V.K.

Glass in ancient China: a problem under dispute. W. P. YETTS. *Illus. London News*, **184**, 732–33 (1934).—The question whether glass was a product of native Chinese industry in early times or an imported commodity is discussed in the light of the Lo-Yang finds, which are earlier than the traditional date of origin of Chinese glass. Colored illustrations. H.H.S.

Glass as building material and metal substitute. I. I. KITAIGORODSKIĬ. *Keram. i Steklo*, **10** [4], 18–20 (1934).—A general discussion of possibilities of glass in the building industry is given. M.V.K.

Glass as an insulator. W. HANLEIN. *Electrotech. Z.*, **54**, 547 (1933).—To make clear the wide adaptability of various types of glass to the electrical industries, the properties of glasses are described in detail. The specific electrical resistance at room temperature varies between 10^{11} and 10^{20} ohms. Resistance varies with temperature according to the law $\log\rho = A/T + B$, where ρ is specific resistance and T is absolute temperature. Dielectric strength, flashover resistance, surface resistance, dielectric loss, dielectric constant, viscosity, tensile strength, compression strength, density, thermal properties, and chemical properties of different glasses are discussed in general terms, and it is concluded that suitable glasses can be developed to equal or surpass other insulating material.

J.T.L.

Glass-vessel manufacture. JACKSON BROS., LTD. *Elec. Rev.*, **114** [2952], 902 (1934).—A brief account is given of the Headland Glass Works, Knottingley, England. Bottles, vases, and small glassware are the products. The sizes and types of electric motors used are given. A conveyer, mixer, and bucket elevator for raw materials and a glass tank under repair are shown. J.L.G.

International Commission for Glass Technology formed. J. C. H. *Bull. Amer. Ceram. Soc.*, **13** [8], 205–206 (1934).

Investigating the rare earth content in sands for glass-melting. A. FIOLETOVA. *Keram. i Steklo*, **10** [5], 3–5 (1934).—The effects of MnO, Cr_2O_3, V_2O_5, and ZrO_2 on glass are discussed, and analyses of eight sands used in glassmelting in U.S.S.R. are presented. M.V.K.

Investigation of the viscosity and plasticity of fused slags and rocks. M. P. VOLAROVICH. *Jour. Phys. Chem.* [U.S.S.R.], **4** [6], 807–14 (1933).—The viscosity of slags and of basalt was measured at temperatures up to 1400° in an apparatus with a rotating platinum cylinder. The results obtained for synthetic slags of the system CaO–Al_2O_3–SiO_2 were compared with data of A. L. Feild and R. S. McCaffery. They showed satisfactory agreement in the region of low viscosities, while for high viscosi-

ties the values obtained by V. greatly exceeded those of both Feild and McCaffery. V. explains this by the slip on the walls of graphite cylinders which, even in McCaffery's apparatus, was not altogether eliminated. Titanous slags obtained in experimental melting of Ural ferrotitanium ores, conducted by E. V. Britzke's method, exhibited low fusion point. Within a short temperature interval their viscosity changed still more rapidly than with ordinary glasses. In the same interval, the titanous slags exhibited manifest plasticity, which was probably due to the incipient crystallization. The viscosity-temperature curve obtained for basalt at temperatures of 1400° down to 1180° strongly resembled the corresponding curves of ordinary glasses. Below 1180° the viscosity of basalt rose more steeply and an appreciable plasticity appeared, which, as in the case of slags, was probably also a token of slow crystallization taking place.

(*J.S.G.T.*)

Lead crystal glass and its investigation from a hygienic standpoint. P. KEIM AND FR. RAEDER. *Tech. Gemeindeblatt*, **36**, 281–83 (1933).—Pb is not dissolved from Pb glass by acid solutions in amounts sufficient to affect health, and as foods are not alkaline its solubility in alkaline solutions is not important hygienically. See also *Ceram. Abs.*, **12** [3], 116 (1933). (*C.A.*)

Leer uses principle of convection for heating ware. FRED M. JOHNSON. *Ceram. Ind.*, **23** [2], 67–68 (1934); *Glass Ind.*, **15** [7], 151–52 (1934).—A new type direct-fired leer of the continuous wire-mesh belt type, 6 ft. inside width of conveyer by 75 ft. long, has been placed in operation by the Macbeth-Evans Glass Co., Elwood, Ind. The leer has no muffles, stacks, or exhaust fans, the heating being accomplished largely by convection. Natural gas is used as fuel. The firing system consists of units located on each side of the leer and extending for approximately one-third its length. Heating by convection, uniform heat distribution over a 72-inch conveyer by recirculation, and increased rate of cooling by using pressure air give this leer an unusually rapid rate of annealing. Extreme flexibility of operation, ease at which the time-temperature cycle can be changed, low operating costs, and quality of annealing make the leer an outstanding installation. Illustrated.

E.J.V.

Manufacturing quartz glass, its properties and applications. M. A. BESBORODOV. *Keram. i Steklo*, **10** [3], 3–10 (1934).—The chief difficulties encountered when producing quartz glass are (1) high temperature of melting the glass, (2) use of a suitable refractory to resist the high melting temperature without destruction, deformation, and reaction with the quartz glass, (3) high viscosity of quartz glass which belongs to the type of "short" glasses and which greatly affects its refining, and (4) high volatility of silica at high temperatures. The main properties of quartz glass are (*a*) high temperature of softening, (*b*) exceptional thermal stability, (*c*) low coefficient of dilatation, (*d*) great permeability to ultraviolet rays, (*e*) dielectric properties, (*f*) behavior in the high-frequency field, and (g) high chemical stability. These properties are discussed in detail and the uses of quartz glass in various industries are enumerated. The technological process of producing nontransparent quartz glass in Russia at present is based on the melting of quartz sand in an electric furnace and in drawing tubes out of the melted mass. For obtaining transparent glass, pure rock-crystal (almost pure silica) is crushed and melted in a vacuum in a high-frequency induction furnace. Details of difficulties encountered and results obtained are given.

M.V.K.

Measurements of optical constants of glass. H. W. LEE. *Glass Ind.*, **15** [7], 141–44 (1934).—L. discusses methods of measuring optical properties of glass from the time Snell discovered the relationship between the angle of incidence and the angle of refraction of a ray of light in 1621. The Abbé system, the Parsons Glass Co. (England) and Jena Glasswerke (Germany) system, Wenham's method of comparing dispersive powers of glasses with that of standard crown glass, and spectroscopic measurements for accurate refractometry are described in detail. Illustrated.

E.J.V.

Mechanism of activated diffusion through silica glasses. RICHARD M. BARRER. *Jour. Chem. Soc.* [London], pp. 378–86 (April, 1934).—Measurements were made of the velocity of diffusion of helium, hydrogen, oxygen, nitrogen, argon, and air through fused silica glass at temperatures ranging between room temperature and 1000°. The diffusing gases can migrate according to two mechanisms. Helium, hydrogen, and neon can pass through the "lattice" of fused silica at high temperatures. The heavy gases, oxygen, nitrogen, and argon, migrate mainly through slip-planes. At low temperatures helium, hydrogen, and neon also show slip-plane diffusion. There is evidence that migration proceeds from the adsorbed layer, not directly from the gas phase. The interaction has been shown to be physical and the gases migrate as undissociated molecules. Calculations have been made using the known laws of interaction of hydrogen, helium, and argon which give energies of the correct order for reasonable pore diameters and indicate "lattice" migration for helium and hydrogen.

M.V.K.

Method for precise measurement of optical path difference, especially in stressed glass. R. W. GORANSON AND L. H. ADAMS. *Jour. Franklin Inst.*, **216** [4], 475–504 (1933).—A description is given of some of the methods previously used to measure small phase differences in polarized light. The method devised was an attempt to increase the accuracy of the best of the previous methods by a hundredfold. Elliptically polarized light is converted to plane polarized light of a certain azimuth by a suitable compensator, and this angle of azimuth is measured. The theory of the functioning of the equipment is developed in detail and the necessary precautions to assure accuracy are indicated. The equipment may be applied to petrographic microscopes or may be constructed as a separate polarimeter for larger specimens. The accuracy obtained was about one hundred times that given by the devices commonly used.

J.T.L.

Modern industrial glasses. EMILIO GOIG. *Quimica & Ind.*, **11** [121], 25–31 (1934).—G. discusses different types of safety glass.

M.V.K.

Neophane glass as a nautical help against blurred vision. F. DAMMEYER. *Glashütte*, **64** [4], 49–50 (1934).—When viewing a spectrum through neodymium glass, the yellow is cut out, the green and red being made sharper in definition, so that a scene or an object can be observed

(even the face of the sun). When used in spectacles on river and sea-going vessels, this neodymium glass renders a ship's details, *e.g.*, color of hull, funnels, flag, etc., much clearer; in hazy weather details can be picked out. Without the neophane glass the ship merges into the background. In thick fog, although no penetration of this curtain by eye is possible, even with the neophane glass, it helps to relieve eye-strain. Good vision is possible at night when red and green navigation lights are clear. See also *Ceram. Abs.*, **13** [1], 9 (1934). M.V.K.

Origin of German glass industry. HUGO KÖHL. *Glashütte*, **63** [45], 739–40 (1933).—The art of glass-making in Germany dates from the 10th Century. The works were originally established in the forests where timber was available as fuel for the furnaces, the wood ashes providing potash and lime, while sand was procurable locally. Old German glass shows an alumina content of 8%, from which it is assumed that the batch contained clay and more probably calcareous marl. German glassware established a character of its own from the beginning, particularly in design and ornamentation, and maintained it in spite of Venetian influence. M.V.K.

Pharmaceutical containers and their durability. W. R. LESTER. *Glass Ind.*, **15** [7], 139–40 (1934).—The phases of the glass durability problem of primary interest to the glass and pharmaceutical manufacturer are (1) weathering: development of surface films and deposits during storage of the empty containers; (2) spalling: chipping and cracking of the glass surface during washing or sterilizing operations; (3) solubility: development of chemical reactions between the inner glass surface and the contained material during the life of the complete package. As the consumer is developing methods and specifications for durability, the manufacturer is forced to use many different methods for testing the ware. Proposed tests for pharmaceutical ware are discussed. E.J.V.

Phosphate glasses. ANON. *Ind. chimique*, **20** [239], 949 (1933).—Silica is partly or entirely replaced by aluminium phosphate in glasses manufactured according to the I. G. method. These glasses have the advantage of being transparent to ultra-violet rays. M.V.K.

Practical data on building and starting the operation of a tank furnace. B. F. KUZMICH. *Keram. i Steklo*, **10** [1], 16–22 (1934).—The special properties such as the coefficient of linear expansion of grog brick, grog block, and Dinas brick used in building a tank furnace are discussed. Directions for putting a new tank furnace into operation are given. M.V.K.

Principles of correct construction of burners for glass-melting furnaces. M. D. TAMARIN AND A. S. RUGA. *Keram. i Steklo*, **10** [3], 30–35 (1934).—A discussion of various burners, their importance in glassmelting, and the unsatisfactory work performed by burners used in Russian glassmelting furnaces is given. Illustrated. M.V.K.

Replacing lead oxide by other oxides in electrotubing glass. I. I. KITAIGORODSKIĬ AND A. I. POLINKOVSKAYA. *Keram. i Steklo*, **10** [1], 39–41 (1934).—In a basic glass of 61 SiO_2, 25 PbO, 1 Na_2O, and 7% K_2O, PbO was partly replaced by various amounts of MgO, CaO, ZnO, and BaO. A series of pure lead glasses was studied. It was found that (1) barium oxide can partly replace lead oxide because of an almost identical viscosity at temperatures below 1200°, similarity of softening points, and specific gravity; (2) zinc oxide in small quantities (5%) may partly replace lead oxide; (3) magnesium oxide in amounts from 5 to 15% can not replace PbO; (4) the introduction of CaO instead of PbO considerably changes the physical and chemical properties of the glass and can not be used. M.V.K.

Researches on rupture. K. H. BORCHARD. *Glashütte*, **64** [8], 115–18; [9], 152 (1934).—B. discusses the durability and crushing strength of glass bottles. The experiments were on (1) rate of rupture without outside strain, (2) rate of rupture under load, (3) radiating rupture, (4) bottom rupture, (5) manipulated rupture, (6) longitudinal rupture, and (7) testing of stresses and rupture. Illustrated. M.V.K.

Researches on softening of vitreous bodies. E. RENCKER. *Compt. rend.*, **198** [6], 571–73 (1934).—A vitreous body seems to soften at the temperature at which its expansion coefficient suddenly increases. This phenomenon was studied by the velocity with which a needle penetrates into the body under the action of a spring at constant temperature. Vitreous Se, anhydrous boric acid, xylonite, and pollopas were used. The curves indicate the changes of plasticity with temperature and show clearly the discontinuity point where the fluidity of the glass, inversely proportional to its viscosity, passes suddenly from zero or a very small value to a measurable quantity. The phenomenon is analogous in this point to the fusion of crystallized substances. M.H.

Rôle of ammonium salts in glassmelting. N. I. SAMSONOV. *Keram. i Steklo*, **10** [1], 23–25 (1934).—The use of NH_4Cl, NH_4NO_3, $(NH_4)_2SO_4$, and $(NH_4)_2CO_3$ in glassmelting is discussed. It has been found that $(NH_4)_2SO_4$ has the best effect as to the rate of melting and $(NH_4)_2CO_3$ the most harmful effect; NH_4NO_3 increased the rate of melting, but the glass was unsatisfactory. Nadel's paper (*Ceram. Abs.*, **11** [11], 558 (1932)) on ammonium salts as addition to the batch is analyzed. S. concludes that the chemical process occurring between Na_2CO_3 and $(NH_4)_2SO_4$ has a good influence on the physical state of the batch, *i.e.*, the ammoniac formed from ammonium sulfate displaces the air in the batch and accelerates the rate of the formation of glass, while the remaining product of the reaction, Na_2SO_4, promotes the refining of the glass. Ammonium salts may be used in glassmelting only in batches containing soda; K_2O can not be used because of the formation of K_2SO_4 which is difficult to disintegrate. M.V.K.

Safety glass industry. FRITZ OHL. *Chem.-Ztg.*, **58** [21], 215–17 (1934).—A general review is given of (1) the development of the safety glass industry, (2) applications of safety glass, (3) raw materials used, glass, intermediate layer, adhesives, cementing of the edges, and (4) contrivances used in manufacture. Bibliography. See also *Ceram. Abs.*, **13** [4], 85 (1934). M.V.K.

Saving of fuel costs for floaters in the new tempering of glassmelting tanks. ANON. *Glashütte*, **63** [50], 847–48 (1933).—An account is given of a successful attempt to heat up a floating bridge when heating the tank furnace. The bridge was imbedded in 30 cm. cullet

and, after three days' heating (melting), was raised to its final position. M.V.K.

Simple equipment for working with filter crucibles. PRAUSNITZ. *Chem. Fabrik*, **7** [19–20], 191 (1934).—A new glass filter crucible developed by the Jenaer Glaswerk is described. M.V.K.

Smoke of the workshop (deposits formed on glass during its melting, working, cooling, and further working). LUDWIG SPRINGER. *Fachausschussber. Deut. Glastech. Ges.*, No. 22, pp. 13–18 (1933); abstracted in *Chim. & ind.*, **31** [5], 1135 (1934).—All deposits formed on the glass surface during melting and working, and later when it is worked over a blast burner, are called "smoke of the workshop." This defect appears in the form of a superficial white deposit resembling devitrified glass. It is eliminated by washing and is different from the "fired smoke of the workshop" which is almost impossible to remove. Mostly sulfates are found in the composition of these fumes when glasses are worked at high temperature. Carbonates, alkaline hydrates, sometimes lime, and tar particles are found at lower temperatures corresponding to those of the cooling or working of the glass. The presence of sulfurous acid in the furnace gases promotes the formation of the white deposits. All glasses are liable to this defect independent of their nature, especially soft glasses. M.V.K.

Stones in glass and devitrification. A. GRANGER. *Céram., Verrerie, Émail.*, **1** [8], 389–92 (1933); **2** [1], 5–6; [2], 53–54; [3], 101–108; [4], 149–54 (1934).—Stones in glass come from the pot, unfused components of the batch, or devitrification. The last is the most important and most difficult to control. Analysis of stones in glass is possible only by the combined use of the petrographic microscope and chemical analysis. G. discusses in detail the analysis of stones and gives a complete table of the optical properties of minerals found in devitrified glass. A devitrification chart of common glasses, compiled by Peddle, is included. M.H.B.

Strength of glass. K. H. BORCHARD. *Glashütte*, **64** [4], 47–48 (1934).—The effect of time when measuring the glass is pointed out, and examples are given from the researches of Hermann and of Grenet in illustration. Experiments on permanent loading show a logarithmic relation between the strength of the material and the time of load. Bibliography. M.V.K.

Sulfur and selenium in the coloring of glasses. ANON. *Ind. chimique*, **21** [241], 149 (1934).—Yellow glasses are usually obtained by adding coal, but the coloring is due to the sulfur present as an impurity. The study of the volatility of sulfurous compounds showed the necessity of operating with weak concentrations in colored ions. Oxidizing fusions yield pink glasses with selenium, while reducing fusions produce yellow or brown glasses. The oxidizing or reducing rate of the fusion greatly influences the volatilization of selenium introduced in the form of sodium selenide. The losses due to volatilization reach 90 to 95% of the quantity of selenium added over 0.6%. Colored glasses are obtained also with a mixture of cadmium sulfide and sodium selenide. The coloring is related to the presence of zinc oxide. The intensity of coloring of potash-lime glasses by cadmium selenide is directly proportional to the zinc oxide content. M.V.K.

Theory and practice of the production of selenium rubies. I. I. KITAIGORODSKIĬ. *Keram. i Steklo*, **10** [5], 5–9 (1934).—After a detailed discussion of the researches of Rooksby (*Ceram. Abs.*, **11** [12], 611 (1932)) and of Bigelow and Silverman (*ibid.*, **12** [7], 253 (1933)) on selenium ruby glasses, K. discusses the following experimental data obtained in Russia: (1) All red selenium glasses are divided into (*a*) stable and (*b*) unstable glasses. Glasses of the first group do not change their color during refining, working of the ware, annealing, or thermal treatment. Glasses of the second group change during all these stages from yellow to red to canary. (2) Glasses (*a*) are colored by stable selenium compounds; glasses (*b*) are colored by selenium. (3) The conclusions of Rooksby are confirmed as to the facts that a stable red glass is obtained only when a solid solution of cadmium selenide and sulfide is used as a pigment and that the color tone of the glass depends on the proportion of cadmium selenide to cadmium sulfide in the solid solution. Rooksby's conclusions dealing with the cause of instability of color in selenium glasses were not confirmed. Tests showed that the instability of color is due to cadmium selenide and cadmium sulfide which have not had time to produce a solid solution and, because of an insufficiently reducing atmosphere, a part of the mixture oxidizes forming various unstable compounds. The basic conditions for obtaining a stable color lie in the pigment, method of its preparation, and conditions of melting the glass mass, especially in the first stages. (4) Of special importance are the preparation of the batch and the presence of a reducer when coloring glasses colloidally with free selenium. The conditions of melting, temperature, and atmosphere are also important. The introduction of electrolytes and the amount and nature of electrolyte influence the colloidal coloring of the glass with free selenium. (5) When metallic selenium is introduced into the glass mass under certain conditions (mixing it with cadmium sulfide in the presence of zinc oxide and a reducer), the coloring of the glass is similar to that when the pigment is introduced in the form of a solid solution. It is difficult to obtain glasses of stable color when using metallic Se if the melting conditions are not carefully controlled. (6) When manufacturing hollow ware and crystal glass, selenium glasses which obtain their color after the thermal treatment are to be preferred for obtaining the whole scale of color tones. (7) Red selenium-soda-calcium-silica glasses were produced. The results of ultra-microscopic investigation of samples of selenium glasses are dealt with. A detailed examination showed that it is not possible to reject the theory of the colloidal coloring of selenium glasses. M.V.K.

Thermal insulation of tank-furnace crowns. G. SH. SHAKIROV. *Keram. i Steklo*, **10** [5], 30 (1934).—The importance of thermal insulation and practical directions for erecting thermal insulation of tank furnace crowns are dealt with. M.V.K.

Tradition of the elders. FRANK W. PRESTON. *Glass Ind.*, **15** [7], 145–46 (1934).—P. states that most of the work in the glass industry is based on traditional methods and shows that the inertia is that of its personnel. Able chemists, producing remarkable results, have been physical chemists. Since most of the properties for which glass is valued are purely physical properties, the glass industry

should attract able chemists to its research staffs. E.J.V.

Transparency of window glass to light and heat rays. E. ERK. *Gesundheits-Ing.*, **57** [19], 237–38 (1934).—E. takes up the weakening of rays by reflection and absorption, laws of absorption, relationship of absorption coefficients to wave-lengths, conversion of sun's rays to rays of lower temperature, Wien's displacements laws, and heat-insulating glasses. E.J.V.

Viscosity of basalt glass at high temperatures. I. KOICHI KANI. *Proc. Imp. Acad.* [Tokyo], **10**, 29–32 (1934).—The viscosity was measured by the rotation of a cylinder immersed in molten glass. The true viscosity was obtained by comparison with rice jelly, with which the accuracy of the method was checked. (*C.A.*)

What the sheet glass artist and merchant must know about the manufacture and properties of white sheet glass. RUDOLF LEHMANN. *Glashütte*, **64** [3], 35–37; [7], 99–100; [8], 119–20 (1934).—A comprehensive survey is given of (1) present manufacturing methods in production of sheet glass, (2) types of glasses produced, (3) composition, (4) properties, (5) effect of melting conditions and working on various properties, (6) testing of glass, and (7) uses. M.V.K.

Window will revolutionize building methods. JOHN D. BIGGERS. *Ceram. Ind.*, **23** [2], 70 (1934); *Glass Ind.*, **15** [7], 152 (1934).—A double-glazed window, Thermopane, consists of two panes of glass fitted to each window sash to provide a dehydrated air space between, which reduces the flow of heat and cold. The Thermopane principle, besides preventing frost formation, eliminates condensation on the glass unless the inside humidity is excessively high. E.J.V.

Yellow etching with other colored etchings for glass. LUDWIG SPRINGER. *Glashütte*, **64** [8], 118–19 (1934).—When covering a light blue glass with the yellow etching and firing, a green etching of the glass is obtained; when using a deep blue glass and a yellow etching rich in silver and, after firing, etching the glass in a hydrofluoric acid bath, original and variegated (blue-green to yellow, dull white, and marbled) glasses are obtained. When a normal yellow etching is fired on a deep blue glass, a beautiful violet etching is obtained; with violet glasses and the same treatment, the etching becomes sky-blue. Numerous color effects can be obtained with colored basic glass and yellow etching; these effects can be varied with a reducing firing. See also *Ceram. Abs.*, **13** [1], 3 (1934). M.V.K.

BOOKS

Safety Glass, "Triplex" (Bezoskolochnoe Steklo "Triplex"). N. I. AMOSOV. *Ukrgizlegirom, Kharkov*, 1933, 79 pp.; reviewed in *Keram. i Steklo*, **10** [3], 44 (1934).—A detailed description of all stages of manufacturing safety glass according to the method of pressing in an autoclave is given. See also *Ceram. Abs.*, **12** [1], 11 (1933). M.V.K.

Structure of Glass (Stroenie Stekla). M. A. BESBORODOV. Goshimizdat., 1933. 208 pp. Price 5 R 50 kopecks. Reviewed in *Keram. i Steklo*, **10** [3], 44 (1934).—This book is a compilation of articles written by Russian and foreign authorities dealing with (1) process of devitrification, (2) conversion of the viscous state into the brittle state, (3) studies of the structure of the glass surface layers, and (4) application of X-rays in the study of the glass structure. M.V.K.

PATENTS

Annealing kilns for sheet glass. A. SCHILD. Ger. 589,676, Nov. 30, 1933. Annealing kilns with fixed hearths for separate sheets of glass (Stracou), consisting of a number of chambers adjacent to each other, are provided with gas-tight sliding doors to shut off one chamber from another. (*J.S.G.T.*)

Apparatus for blowing articles from glass tubing. JAKOB DICHTER. Fr. 752,723, Sept. 29, 1933. (*C.A.*)

Apparatus for cutting flat glass. PILKINGTON BROS., LTD., J. GASKELL, AND J. B. WATT. Brit. 412,925, July 18, 1934.

Apparatus for delivering measured quantities of molten glass. OLIVER M. TUCKER, WM. A. REEVES, AND JAMES M. BEATTY. Ger. 592,457, Feb. 8, 1934. This corresponds to Brit. 258,228, Sept. 14, 1925. (*C.A.*)

Apparatus for drawing glass tubes. LEOPOLDO SANCHEZ-VELLO. Ger. 579,506, June 28, 1933. (*C.A.*)

Apparatus for drawing sheet glass. DANIEL ADAMS (Libbey-Owens-Ford Glass Co.). U. S. 1,967,047, July 17, 1934.

Apparatus for drawing sheets of glass. N. V. HOLLANDSCHE MIJ. VOOR DE VERVAARDIGING VAN GLAS. Fr. 756,685, Dec. 13, 1933, and 757,403, Dec. 26, 1933. (*C.A.*)

Apparatus for flowing and distributing molten glass. L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 1,967,378, July 24, 1934.

Apparatus for grinding the edges of glass sheets. WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 1,966,869, July 17, 1934.

Apparatus for hardening glass or metal plates by air cooling. LEONARDO MOSMIERI AND GINO DAL PINO. Ger. 595,152, April 3, 1934. (*C.A.*)

Apparatus for making brick, etc., from molten slag. DET NORSKE AKTIESELSKAB FÜR ELEKTROKEMISK INDUSTRI. Fr. 761,945, March 30, 1934. (*C.A.*)

Apparatus for making glass sheets by vertical drawing. N. V. HOLLANDSCHE MIJ. VOOR DE VERVAARDIGING VAN GLAS. Fr. 756,720, Dec. 14, 1933. (*C.A.*)

Apparatus for making laminated sheets of glass. SCHLESISCHE SPIEGELGLAS-MANUFACTUR CARL TIELSCH G.M.B.H. Fr. 757,404, Dec. 26, 1933. (*C.A.*)

Apparatus for making nonsplintering glass. ADOLF KÄMPFER AND ADOLF C. PLÖTZE. Ger. 593,016, Feb. 20, 1934. Means are described for applying plastic compositions to glass disks. (*C.A.*)

Apparatus for making plate glass. N. P. KRASNIKOV. Russ. 33,656, Dec. 31, 1933. Construction details are given. (*C.A.*)

Apparatus for making sheets of glass. LIBBEY-OWENS-FORD GLASS CO. Fr. 760,797, March 2, 1934. (*C.A.*)

Apparatus for making spark plugs. T. W. WARREN. U. S. 1,968,665, July 31, 1934.

Apparatus for making tubular glass objects. ALFRED HOFMANN & CIE. Fr. 753,782, Oct. 24, 1933. (*C.A.*)

Apparatus for manufacturing glass cylinders. YUZURU IWASAKI. Japan. 99,910, March 2, 1933. Diagrammatical. (*C.A.*)

Apparatus for producing fibers from glass, slag, or similar fusible material. N. V. MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Ger. 594,764, March 21, 1934; addition to 539,738, *Ceram. Abs.*, **12** [4], 152 (1933). (*C.A.*)

Apparatus for producing glass rods or tubes. HARTFORD-EMPIRE CO. Ger. 594,863, March 23, 1934. (*C.A.*)

Apparatus for the production of glass silk. O. H. A. KRÖGER AND O. A. OSWALD. U. S. 1,968,693, July 31, 1934.

Apparatus for the production of wired glass. JOSEPH GASKELL (Pilkington Bros., Ltd.). U. S. 1,967,932, July 24, 1934.

Apparatus for tempering glass. RAYMOND MEER. Fr. 759,556, Feb. 5, 1934. (*C.A.*)

Apparatus for tempering glass by jets of air. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY, ET CIREY. Fr. 42,533, Aug. 4, 1933; addition to 720,348. (*C.A.*)

Arrangement for preheating the feeding chamber of glassmelting furnaces. V. E. BROMLEY. Russ. 30,815, Aug. 31, 1933. (*C.A.*)

Attachment for preheating the feeder canal of glassmelting furnaces. V. E. BROMLEY. Russ. 30,816, Aug. 31, 1933. (*C.A.*)

Automatic liner feeding mechanism. J. J. WILLIAMS AND JOSEPH BAUMAN (Hazel-Atlas Glass Co.). U. S. 1,967,646, July 24, 1934.

Bottle-blowing machine. E. G. BRIDGES (Lynch Corp.). U. S. 1,968,777, July 31, 1934.

Bottle shipping crate. W. C. KRAUSE. U. S. 1,969,409, Aug. 7, 1934.

Combined blowing and pressing process for making hollow articles from fused quartz. DEUTSCHE-ENGLISCHE QUARZSCHMELZE G.M.B.H. (Freiherr von Beaulieu-Marconnay, inventor). Ger. 595,082, March 28, 1934. (*C.A.*)

Composite sheets of glass. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY, ET CIREY. Fr. 757,502, Dec. 28, 1933. Composite glass is made by heat-welding two or more sheets of glass having different coefficients of expansion, the sheets being heated separately or side by side to temperatures such that their viscosity is between 10^8 and 10^{13} c.g.s. units. (*C.A.*)

Composite vitreous articles. SOCIETÀ ANON. VETRERIA ITALIANA BALZARETTI MODIGLIANI. Fr. 756,657, Dec. 13, 1933. Glass threads are mounted between sheets of glass to give optical, decorative, thermal, or acoustic effects. (*C.A.*)

Compound glass sheets. ADOLF KÄMPFER AND ADOLF C. PLÖTZE. Fr. 751,396, Sept. 2, 1933. The elastic sheet is formed by adding a solution of rubber to a solution of a natural or artificial resin, if necessary with the addition of suppling agents, and afterward vulcanizing the rubber. (*C.A.*)

Continuous apparatus for drawing strip glass. N. V. HOLLANDSCHE MIJ. VOOR DE VERVAARDIGING VAN GLAS. Ger. 594,100, March 10, 1934. (*C.A.*)

Construction of ladles for casting plate glass. SCHLESISCHE SPIEGELGLAS-MANUFACTUR C. TIELSCH G.M.B.H. Ger. 591,499, Jan. 4, 1934. A vessel for ladling, transporting, and casting molten glass has its sides formed by rollers capable of rotation in either direction. (*J.S.G.T.*)

Continuous rolling of wired glass. MISSISSIPPI GLASS CO. Ger. 584,543, Sept. 7, 1933. The glass is allowed to flow out of an opening in the bottom of the tank and wire mesh is fed into the stream at the outlet just before passing through the rolls. (*J.S.G.T.*)

Continuous upward drawing of wired glass. H. KNOBLAUCH. Ger. 584,391, Sept. 7, 1933. In a process of drawing wired sheet glass from a debiteuse, two containers capable of independent control of temperature feed the glass through suitably disposed slits, one on either side, into the central slot of the debiteuse up which the wire mesh is fed. (*J.S.G.T.*)

Contour of roof and bottom of leers. GLACERIES DE LA SAMBRE SOC. ANON. Ger. 583,805, July 24, 1933. The roof of the leer is made substantially flat and the bottom is arched so that it is nearer to the belt in the center than at the sides. (*J.S.G.T.*)

Cooling furnace for glass sheets. ADOLF SCHILD. Ger. 589,678, Dec. 12, 1933. (*C.A.*)

Crucible furnaces for fusing glass. MAURICE É. V. DELOT AND GEORGES A. DELACROIX. Fr. 761,156, March 13, 1934. (*C.A.*)

Cylindrical fusion furnace for glass, etc. FRANÇOIS SCHWALLER. Fr. 753,472, Oct. 17, 1933. (*C.A.*)

Drinking tumbler. B. O. REUTHER (Minnie F. Steele and Edna S. Reuther). U. S. 1,968,263, July 31, 1934.

Electric furnace for melting glass. PATENT-TREUHAND-GES. FÜR ELEKTRISCHE GLÜHLAMPEN M.B.H. Fr. 756,498, Dec. 11, 1933. (*C.A.*)

Eyeglass construction. G. E. NERNEY (Bay State Optical Co.). U. S. 1,969,145, Aug. 7, 1934.

Feeding glass from a tank furnace to a casting ladle. A. SCHILD. Ger. 589,849, Dec. 7, 1933. In a method of feeding glass from a tank furnace to a ladle for casting purposes by means of a guiding member interposed between the two, the ladle and guide member are carried on a platform adjustable as to height. (*J.S.G.T.*)

Feeding glass sheets from forming machine to leers. LAMBERT VON REIS (American Bicheroux Co.). U. S. 1,967,638, July 24, 1934.

Felting glass or slag wool. W. RÖSSLER. Ger. 581,677, July 13, 1933. In a process of compacting glass or slag wool into mats or molded shapes for use as insulating material, the glass threads from the drum of the spinning machine, after being cut to the correct length, fall into a collecting funnel from which they are drawn out as an endless band which is compacted by passing through rollers and is then cut to shape by circular knives. (*J.S.G.T.*)

Folding mold for glassblowing. L. V. BELOVA AND A. P. GALUSHKIN. Russ. 31,100, Sept. 30, 1933. (*C.A.*)

Furnace for hardening glass plates. "MÜHLIG-UNION"

GLASINDUSTRIE A.-G. Ger. 591,967, Jan. 30, 1934. (*C.A.*)

Fusion furnace for glass, etc. BRITISH HARTFORD-FAIRMONT SYNDICATE, LTD. Fr. 759,699, Feb. 7, 1934. (*C.A.*)

Gathering glass by suction and transferring parisons. E. HAGENMEYER. Ger. 584,390, Sept. 7, 1933. The two-table machine gathers its glass by suction while revolving and then transfers it by means of the neck mold to the finish mold while the tables are still, these coming to rest so that no parison mold is over the forehearth. (*J.S.G.T.*)

Glass. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Fr. 752,548, Sept. 25, 1933. A perforated pouring device, the perforations of which increase in size from the interior to the exterior, is described. (*C.A.*)

Glass. HARTFORD-EMPIRE CO. Fr. 760,561, Feb. 26, 1934. Means for charging the furnace is given. (*C.A.*)

Glass. I. G. FARBENIND. A.-G. Fr. 751,524, Sept. 5, 1933. Colorless glass of high resistance to water and permeable to ultra-violet rays is composed for the greater part of Ba metaphosphate. Metaphosphates of Ca and Mg may also be present. (*C.A.*)

Glass. JENAER GLASWERK SCHOTT & GEN. Fr. 754,029, Oct. 30, 1933. A glass which is not attacked by metal vapors contains boric acid 10 to 40%, Al_2O_3 10 to 35%, and bivalent oxides the rest. The content of BaO is preferably at least 40%. The total of quadrivalent oxides, alkalis, and oxides of Sb, As, and Pb should not exceed 5%. (*C.A.*)

Glass. "OSA" PARTICIPATIONS INDUSTRIELLES (SOC. ANON.). Fr. 760,329, Feb. 20, 1934. Silicic acid for use in making glass which is permeable to ultra-violet rays is obtained by precipitation from industrial solutions of soluble glass. The precipitated acid is washed with dilute H_2SO_4 containing H_2O_2 until the content of oxides of Ti and Fe is below 0.005%. (*C.A.*)

Glass. PATENT-TREUHAND-GES. FÜR ELEKTRISCHE GLÜHLAMPEN M.B.H. (Werner Düsing and Johann Enss, inventors). Ger. 593,687, March 1, 1934. Glass transparent to ultra-violet rays is made by fusing SiO_2, obtained by precipitation from water-glass solution by acid, with other usual glassforming materials. (*C.A.*)

Glass. PITTSBURGH PLATE GLASS CO. Fr. 760,998, March 7, 1934. A glass which absorbs ultra-violet rays but which allows over 84% of the visible rays to pass through a thickness of 2 mm. contains 0.2 to 1% of Fe_2O_3, the only coloring oxide present. (*C.A.*)

Glass. SOC. ANON. D'ÉTUDES ET DE CONSTRUCTIONS D'APPAREILS MÉCANIQUES POUR LA VERRERIE. Fr. 751,357, Sept. 2, 1933. Means for continuous withdrawal of glass from the furnace is given. See also *Ceram. Abs.*, **12** [8], 297 (1933). (*C.A.*)

Glass. SOC. DES VERRERIES DE FOLEMBRAY (François Doutriaux and Lucien Lavère, inventors). Fr. 753,908, Oct. 27, 1933. A new glass contains SiO_2 less than 70, B_2O_3 12 to 25, Na_2O 5 to 8, PbO 2 to 10, and Al_2O_3 1 to 5%. Good results are obtained with SiO_2 67, B_2O_3 20.26, Na_2O 6.49, PbO 3.9, and Al_2O_3 2.37%. (*C.A.*)

Glass. WM. C. TAYLOR (Corning Glass Works). Can. 340,573, April 3, 1934. A glass consisting of SiO_2 72, MgO 12, B_2O_3 8, Na_2O 6, and K_2O 2% has a linear coefficient of expansion of approximately 0.0000046, is clear, can be reworked in the flame without crystallizing, and possesses good chemical stability. In general, other second-group metals, particularly Zn, Ca, or Ba, may be substituted for Mg in the above composition without causing crystallization, although the expansion coefficient will be subject to slight change. The ratio of Na_2O to K_2O may vary from 1 to 3. (*C.A.*)

Glass. VERRERIE CRISTALLERIE D'ARQUES G. DURAND & CIE. Fr. 761,212, March 14, 1934. The charge is melted in open crucibles, then, after fusion, to work the molten glass, the crucibles are covered. An apparatus is described. (*C.A.*)

Glass. WERNER MÜLLENSIEFEN. Ger. 595,452, April 11, 1934. Glass strip cased with glass of different properties is produced by spraying powdered glass, preferably preheated, on to the freshly drawn strip. (*C.A.*)

Glassblowing apparatus for making electric bulbs. I. N. GOLLENSKIĬ. Russ. 31,587, Oct. 31, 1933. Construction details are given. (*C.A.*)

Glass composition for electrical discharge devices. MARCELLO PIRANI, MARTIN REGER, AND GEORG GAIDIES (General Electric Co.). U. S. 1,969,277, Aug. 7, 1934. A glass containing between 40 to 60% boric oxide (B_2O_3), 4 to 5% sodium oxide (Na_2O), 10 to 11% calcium oxide (CaO), 11 to 13% alumina (Al_2O_3), and 20 to 30% silica (SiO_2) is described.

Glassforming machine. J. F. RULE (Owens-Illinois Glass Co.). U. S. 1,967,452, July 24, 1934.

Glassmelting furnace. RUDOLF BALDERMANN. Ger. 594,615, March 19, 1934. (*C.A.*)

Glassmelting furnace with a gas producer. N. A. SHELUDYAKOV. Russ. 33,652, Dec. 31, 1933. Construction details are given. (*C.A.*)

Glassware annealing leer. GARLAND LUFKIN (Owens-Illinois Glass Co.). U. S. 1,967,365, July 24, 1934.

Hardening glass. RUDOLF SEIDEN. Austrian 136,536, Feb. 10, 1934. Sheet glass is hardened by heating different parts of the sheet simultaneously to different temperatures. Methods of procedure are indicated. (*C.A.*)

Ladling device for a glassmaking machine. A. A. ZAITZEV. Russ. 31,588, Oct. 31, 1933. Construction details are given. (*C.A.*)

Leer. LAMBERT VON REIS (N. V. Mij. tot Beheer en Exploitatie van Octroöien). U. S. 1,967,761, July 24, 1934.

Leer feeder. BYRNE MCGOVERN AND A. O. KETCHEM (Owens-Illinois Glass Co.). U. S. 1,967,366, July 24, 1934. E. E. MILNER (Ball Brothers Co.). U. S. 19,253, July 24, 1934 (reissue).

Leering glass sheets. RICHARD GENENGER (American Bicheroux Co.). U. S. 1,967,613, July 24, 1934.

Machine for working glass. V. L. RONCI (Bell Telephone Laboratories, Inc.). U. S. 1,969,525, Aug. 7, 1934.

Means for conveying goods through annealing furnaces. BENNO SCHILDE MASCHINENBAU A.-G. Ger. 557,254, Nov. 1, 1928; and 594,565, March 19, 1934.

Means for facilitating the cutting of laminated glass. W. B. CHASE. U. S. 1,969,394, Aug. 7, 1934.

Method and apparatus for drawing glass tubing. CORNING GLASS WORKS. Brit. 413,614, July 25, 1934.

Method and means for heat-treating glass articles. CORNING GLASS WORKS. Brit. 413,591, July 25, 1934.

Mold for glass vessels. SOC. ANON. D'ÉTUDES ET DE CONSTRUCTIONS D'APPAREILS MÉCANIQUES POUR LA VERRERIE. Fr. 757,536, Dec. 28, 1933. (*C.A.*)

Mold for glassware. LOUIS POGLEIN (McKee Glass Co.). U. S. 1,969,577, Aug. 7, 1934.

Nonglare safety glass. J. H. SHERTS (Duplate Corp.). U. S. 1,966,833, July 17, 1934.

Nonsplintering glass. I. G. FARBENIND. A.-G. (Manfred Dunkel, Wilhelm Breuers, and Walter Wolff, inventors). Ger. 593,465, March 2, 1934. Hydrogenated rubber or a hydrogenation product of a polymerized butadiene hydrocarbon is formed into a layer between two glass sheets or is used to unite an intermediate layer of another material, *e.g.*, cellulose acetate, to the glass. (*C.A.*)

Polishing glass. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY, ET CIREY. Fr. 753,909, Oct. 27, 1933. A small amount of salts, particularly chlorides, is added to the water used for mixing with the Fe oxide or emery dust, so as to lower the vapor tension of the water and reduce its speed of evaporation. (*C.A.*)

Process and apparatus for cutting and handling sheet glass. E. G. GREEN (Libbey-Owens-Ford Glass Co.). U. S. 1,967,055, July 17, 1934.

Process of grooving laminated glass. E. H. HAUX (Duplate Corp.). U. S. 1,966,817, July 17, 1934.

Production of ampoules, etc. C. ROSE. Ger. 584,119, Aug. 31, 1933. Tube blanks closed at one end are fed to rolls which by their rotation hold the open end against a blowhead; after suitable heating, mold halves are closed round the softened closed end which is then blown out to shape. (*J.S.G.T.*)

Production of compound glass. MANFRED DUNKEL, WILHELM BREUERS, AND WALTER WOLFF (I. G. Farbenind. A.-G.). U. S. 1,969,397, Aug. 7, 1934.

Production of flashed hollow ware. OBERLAUSITZER GLASFORMENFABRIK SCHULZE & KLUGE. Ger. 582,281, July 27, 1933. The first mold charge of one kind of glass is pressed to shape in the parison mold and then one or more other charges of glass of different color are introduced above this and brought into intimate contact by pressing with a rotatable plunger, after which the parison so formed is transferred to the blow mold and blown out to the finished shape in the ordinary way. (*J.S.G.T.*)

Production of rolled and figured glass sheets. SCHLESISCHE SPIEGELGLAS MANUFACTUR C. TIELSCH G.M.B.H. Ger. 592,954, Feb. 1, 1934. In a process for producing rolled figured sheet of special color or with special physical or chemical properties by blending one or more sheets with a base sheet, the latter is produced continuously by rolling from a furnace in known manner. (*J.S.G.T.*)

Protective glass. VERRERIES DE GOETZENBRUCK S. A. Fr. 752,615, Sept. 27, 1933. A glass which absorbs ultraviolet and infra-red rays contains CdS and FeO, with or without other metal compounds. The fused glass must be protected from the influence of the atmosphere of the furnace by covering the crucibles with refractory materials. (*C.A.*)

Refining glass. CORNING GLASS WORKS. Fr. 756,495, Dec. 11, 1933. Masses of molten glass are refined by adding to the charge to be melted a small amount of material containing Br or I, *e.g.*, I, iodates, iodides, iodoform, bromides, and bromates. (*C.A.*)

Regenerative glassmelting furnace with oil heat. F. S. SEMENOV. Russ. 30,813, Aug. 31, 1933. Construction details are given. (*C.A.*)

Rollers for drawing sheet glass. PILKINGTON BROS., LTD. Ger. 594,233, March 14, 1934. This corresponds to Brit. 398,479, *Ceram. Abs.*, **12** [12], 421 (1933). (*C.A.*)

Rotating basins forming gathering chambers annexed to glass furnaces. SOC. ANON. D'ÉTUDES ET DE CONSTRUCTIONS D'APPAREILS MÉCANIQUES POUR LA VERRERIE. Brit. 412,847, July 11, 1934.

Safety glass. C. F. BOEHRINGER & SOEHNE G.M.B.H. Fr. 758,954, Jan. 26, 1934. The intermediate "layer" is composed of at least 3 distinct layers, the outer 2 of which consist of cellulose esters or ethers or their mixtures, containing 100% or more of jelling or plastifying agents, or of resins with an appropriate amount of softening agents, while the third layer consists of cellulose ester, ether, or hydrate containing a smaller amount of jelling or plastifying agents. The sheets should be such that they do not affect one another in such a way as to modify their properties, *e.g.*, by diffusion into one another. (*C.A.*)

Safety glass. IMPERIAL CHEMICAL INDUSTRIES, LTD. Fr. 758,994, Jan. 26, 1934. The intermediate layer is composed of wholly or partly polymerized vinyl acetate in which is incorporated 5 to 25% by weight of camphor, with or without the addition of other plastifiers and (or) solvents, provided that the total amount of plastifier and (or) solvent, including camphor, does not exceed 35% by weight of the polyvinyl acetate. (*C.A.*)

Safety glass. LOUIS E. NOTTELLE. Fr. 748,856, July 12, 1933. Glass sheets and a plastic sheet having a basis of cellulose esters are immersed in a liquid having a basis of glyceric esters or other nonvolatile solubilizing agents for cellulose esters and are brought together in the presence of the liquid. (*C.A.*)

Safety glass. PROTECTOGLASS, LTD. Fr. 761,657, March 24, 1934. Apparatus for assembling and making the glass is given. Fr. 761,968, March 31, 1934. Apparatus for applying the cellulosic material is described. (*C.A.*)

Safety glass. SOC. GÉNÉRALE D'OPTIQUE SOC. ANON. DES ANCIENS ÉTABLISSEMENTS HUET & CIE AND JUMELLES FLAMMARION. Fr. 761,820, March 28, 1934. Apparatus for introducing the plastic material between the sheets of glass by a difference of pressure is described. (*C.A.*)

Sheet-glass forming apparatus. D. H. GOODWILLIE (Libbey-Owens-Ford Glass Co.). U. S. 1,967,025, July 17, 1934.

Sliding plug for glassmelting furnace. SCHLESISCHE SPIEGELGLAS-MANUFACTUR CARL TIELSCH G.M.B.H. Ger. 592,315, Feb. 5, 1934. (*C.A.*)

Suction-type glass gathering and forming machine. L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 1,967,377, July 24, 1934.

Tilting pots during casting process. FORGES ET ATELIERS DE CONSTRUCTIONS ÉLECTRIQUES DE JEUMONT. Ger. 592,953, Feb. 1, 1934. In a method of casting glass from a pot into the pocket formed by a plurality of rolls mounted on an axis inclined to the horizontal, the tilting axis of the pot is arranged at a more or less acute angle to that of the rolls. (*J.S.G.T.*)

Workholder for lens blanks. O. G. HAUSSMANN. U. S. 1,969,219, Aug. 7, 1934.

Structural Clay Products

Manifestations of deliquescence and efflorescence. A. DAMIENS. *Compt. rend.*, **198** [13], 1233–35 (1934).—D. defines these expressions more exactly and determines the condition of stability of salts in contact with air; the composition of the salt can change either by loss or by absorption of water. He develops a formula for a critical hygrometric condition which, in the case of anhydrous salts, is the temperature above which the salt is deliquescent and below which it is stable. In the case of hydrated salts, two conditions exist, a minimum critical hygrometric value below which the salt is efflorescent, and a maximum critical value above which the salt is deliquescent. Between these values the salt is stable. The critical hygrometric condition is expressed by $(p \times 100)/P$, where p is the vapor tension of the saturated salt solution and P, the saturating water-vapor pressure at a given temperature; for 15°C, P is 12.699. Efflorescence and deliquescence of various salts are determined for several districts in France from the atmospheric conditions in these districts.

M.H.

BULLETIN

Sand-lime brick. G. E. BESSEY. *Dept. Sci. Ind. Research, Building Research, Special Rept.*, No. 21, 62 pp. (1934).—A comprehensive description of materials, process of manufacture, properties, specifications, and tests of raw materials and finished brick are given. (*C.A.*)

PATENTS

Building block and wall construction. F. T. HEATH. U. S. 1,969,402, Aug. 7, 1934.

Building unit. ALBERT HENDERSON (Elverton H. Wicks). U. S. 1,968,393, July 31, 1934.

Cellular clay. CELLULAR CLAY CORP. Fr. 748,315, July 1, 1933. Clay containing a large number of small cells which are hermetically closed with respect to one another is made by mixing a clay containing a carbonate with a diluted acid to a cream and then, while the bubbles formed are in suspension, hardening the mass, which is afterward fired. The expansion of the gas in the cream is regulated by the addition of a hydrophile substance such as plaster. (*C.A.*)

Ceramic product and its manufacture. LUDWIG KERN. U. S. 1,967,311, July 24, 1934. A process of manufacturing ceramic products comprises mixing powdered coal ashes and argillaceous material, plasticizing the mixture with a chloride and grinding, molding the plastic mass so formed, and firing the molded mass.

Construction of road pavements, etc. L. R. H. IRVINE. U. S. 1,966,760, July 17, 1934. A process for the construction of road pavements comprising keyed sections having approximately parallel sides; in this process natural earth material selected from a group consisting of shale, clay, and their equivalents is first drained upon the site of the pavement, then shaped and watered while consolidated by rolling with suitable weight, pugged, puddled, and trimmed to an even surface of the desired shape, the surface being then divided into substantially parallel sided and keyed sections of mutually corresponding shape, then dried, and progressively heated to approximately 1800°F a sufficient length of time for partially fusing and vitrifying the material until a brick hardness is obtained, the interstices between the sections and those which may appear during heating being filled with a suitable binding agent comprising bituminous material, sand, and clay.

Floor and roof construction. J. A. FERGUSON. U. S. 1,968,034, July 31, 1934.

Low thermal conductivity building unit and method of making. C. L. NORTON, ROBERT RICHARDSON, AND W. S. BATEMAN (Babcock & Wilcox Co.). U. S. 1,968,052, July 31, 1934. A method of manufacturing a building block includes the steps of mixing permanent solids with wetting liquids, then coincidentally molding and deliquidizing by centrifugal force, and permanently setting the block.

Manufacture of nailable brick, roofing tile, ordinary tile, etc. G. E. HEYL. Brit. 413,238, July 18, 1934.

Sewer or drain. J. H. RAFFERTY. U. S. 1,966,996, July 17, 1934. A drain or sewer comprises a gutter base running along the side of a street, a curb joined to the gutter base and extending downwardly for a distance below the gutter base for forming one side of the drain, and a confining wall running along the curb inwardly thereof and joined to the gutter base.

Tile wall construction. H. L. WHEELER. U. S. 1,968,728, July 31, 1934.

Veneer brick and means for securing it to a surface. A. A. PEASLEY AND J. C. PECKOSH. U. S. 1,969,148, Aug. 7, 1934.

Refractories

Action of carbon monoxide on refractory materials. I. Experiments on the disintegration of fireclay products by carbon monoxide. W. HUGILL, H. ELLERTON, AND A. T. GREEN. *Trans. Ceram. Soc.* [Eng.], **32** [12], 533–42 (1933); reprinted from *Bull. Brit. Refrac. Research Assn.*, No. 25 (June, 1931). **II.** *Trans. Ceram. Soc.* [Eng.], **32** [12], 543–50 (1933); reprinted from *Bull. Brit. Refrac. Research Assn.*, No. 26 (Aug., 1931); for abstract see *Ceram. Abs.*, **11** [9], 493 (1932).

R.H.H.P., JR.

Chrome-base castable refractory shows merit in steel-heating furnaces. ANON. *Steel*, **94** [7], 28 (1934).—Details as to the use of a chrome-base castable refractory known as Hearth-Crete are given. Illustrated.

M.V.K.

Clayworking in the East. IV. Indian earths, pottery clays, and refractory materials. W. H. BATES. *Brit. Clayworker*, **43** [507], 117–19 (1934).—B. discusses fire clays of India and products manufactured from these clays and gives brief references to the manufacture of silica, magnesite, and chromite brick. For Part III see *Ceram. Abs.*, **13** [9], 236 (1934); see also p. 273.

R.A.H.

Crystallographic elements of silicon carbide. MARTIN A. PEACOCK AND ROBERT SCHROEDER. *Centr. Mineral. Geol.*, **A**, 113–21 (1934). MARTIN A. PEACOCK. *Ibid.*, pp. 121–22. (*C.A.*)

Cupola linings. J. C. GREEN. *Trans. Ceram. Soc.* [Eng.], **33** [6], 241–50 (1934).—The advantages of rammed linings in comparison with brick linings for cupolas are discussed.

R.H.H.P., JR.

Cupola linings. J. G. A. SKERL. *Bull. Brit. Cast Iron Research Assn.*, **3** [7], 170–76 (Jan., 1933).—The composition and properties of materials used for cupola linings are discussed. Given good working conditions in the cupola, especially in regard to the slag, which should be fairly high in lime, the lining must have as high a refractoriness as possible to resist the heat generated by the blast on the hot coke, and under these conditions the choice, which is limited by cost considerations, lies between a highly-bonded aluminous fire brick and a siliceous material containing little bonding. Under conditions where the coke is more ferruginous, probably the highly-aluminous material is to be preferred. (*J.I.S.I.*)

Determination of cristobalite content of silica brick. J. M. G. HENRAR AND J. G. DE VOOGD. *Het Gas*, **53**, 492–96 (1933).—The determination of cristobalite in fired silica brick is of some importance because of the relatively large volume increase in the rapid α-β transition at 230° and its relation to spalling. The Nieuwenburg dilatometer apparatus (*Ceram. Abs.*, **7** [7], 457; [12], 864 (1928)) for cristobalite determination based on the expansion of a small test cylinder is described. The test body of 90% powdered brick (DIN sieve No. 60) + 10% fat clay, kneaded with H_2O and pressed through a 7-mm. glass cylinder, is cut off to 30 mm., dried for 1 hr. *in vacuo* at 50 to 60°, then ground to 30 mm. It is heated in the center of an electric furnace; its expansion is transmitted to a little mirror, 0.01 mm. expansion giving 9 mm. displacement of a light beam on the scale. Several curves of expansion *vs.* temperature rise are given; from these the cristobalite content is derived. The results are reproducible in 1% from tests by 3 independent laboratories. The test cylinders are used only once. Results so far obtained do not point to high cristobalite content as a cause of spalling. (*C.A.*)

Determination of heat conductivity and its temperature coefficient for electrical conductors. R. STÖRMER. *Wiss. Veröffentlich. Siemens-Konzern*, **13**, 30–40 (1934).—The paper is largely mathematical. An electrical method is described, which is applicable up to high temperatures and can be used with small quantities of materials. The method indicates the validity of the Wiedemann-Franz law. It was applied to the determination of the heat conductivity of electrographite and other technical materials. (*B.C.A.*)

Discussion of F. H. Riddle's paper on "Possibility of sillimanite minerals as refractories." F. H. RIDDLE AND C. G. FINK. *Trans. Electrochem. Soc.*, **59**, 50–51 (1931).—The best "super-refractory" sillimanite brick settle less than 0.2% at 1520°C under a load of 50 lb./in.^{2} The spark-plug test is suggested for obtaining an idea of the quality of a material for use as a refractory. See *Ceram. Abs.*, **10** [12], 845 (1931). (*J.I.M.*)

Dolomites and magnesite. J. DAUTREBANDE. *Chaleur & Ind.*, **8**, 266–68 (1927).—The chemical and physical properties of dolomite and magnesite are described and discussed in relation to the use of the materials as refractories. Dolomite should preferably contain not less than 45% of magnesium carbonate, and this percentage should be constant throughout any given specimen; the material should be of compact and uniform texture and nonfriable. Both calcined dolomite and magnesite are used as refractories and for the production of magnesium cement. Calcined dolomite should contain not less than 20% of magnesium and not more than 4% of silica, alumina, and ferric oxide which tend to lower the melting point. Four methods are given for preparing fairly pure magnesium oxide, suitable for use in magnesium cement, from calcined dolomite. (*J.I.M.*)

Effect of various technological treatments on physical properties of sagger mixes. F. A. ZENKOVICH. *Keram. i Steklo*, **10** [5], 13–16 (1934).—Sagger mixes produced according to the wet method have a higher thermal stability but a low mechanical strength, while mixes produced by the "rolled" method possess a higher mechanical strength but have a lower thermal stability.

M.V.K.

Graphite—its winning and use in the metallurgical industry. KARL DOPP. *Zentral.-Europ. Giesserei-Z.*, **4** [11–12], 8–10 (1931).—It is not definitely established what geological or chemical processes have contributed to the formation of this mineral. The two principal theories are that it is the product of vulcanism and that it has resulted from the decomposition of carbon dioxide at low temperatures with the intermediate formation of iron and manganese carbonyls. Another theory postulates the transitory production of titanium-cyanogen compounds. The first graphite deposits were found in Borrowdale in 1564. Other deposits have since been discovered in many other countries. Graphite for crucible manufacture must be free from sulfur and low in ash content. (*J.I.M.*)

Greater efficiency in furnaces with refractory insulation. H. M. CHRISTMAN. *Ceram. Ind.*, **23** [2], 81–86 (1934).—C. discusses heat storage in furnaces, showing how insulation prevents heat loss. Insulation on the interior of furnaces led to the production of refractory insulating brick of good strength, with temperature-resisting qualities equal and superior to the best grades of fire brick, excellent insulating properties, and low heat storage which can satisfactorily be used directly in contact with combustion gases and in heating zones of every description. A comparison of wall constructions of approximately the same

insulating qualities is made as to weight per square foot and approximate heat storage at annealing temperatures. Advantages of refractory insulation are lower weight, reduced lag in changing from one temperature to another, and lower initial cost of walls. Refractory insulated furnaces usually show time and fuel savings greater than calculated probably because (1) their walls become incandescent so quickly and heat the charge more quickly, somewhat in accordance with the principle of the luminous flame burner, and (2) in intermittent furnaces, the furnace or kiln has finished its annealing or firing and has been shut off before the walls have reached an equilibrium condition. Illustrated. E.J.V.

Important characteristics of refractory construction materials for brown-coal stoking. W. MIEHR. *Braunkohle*, **32**, 757–65, 778–83 (1933).—Chemical and physical properties are compared. (*C.A.*)

Insulating old open hearths to improve efficiency. S. M. JENKINS. *Steel*, **91**, 24–26 (Nov. 14, 1932). (*J.I.S.I.*)

Insulating refractories gain more general application. ANON. *Steel*, **94** [1], 132–33 (1934).—A review of progress made in the production and application of insulating refractories is given. M.V.K.

Melting point diagram of refractory oxide mixtures with lime. H. J. REUSCH AND H. VON WARTENBERG. *Heraeus Vacuumschmelze 10th Anniv. Vol.*, p. 349 (1933).—Lime forms eutectics with Cu_2O (28% CaO, 1140°), BeO (50% CaO, 1470°), ThO_2 (24% CaO, 2300°), Mn_3O_4 (15% CaO, 1450°), NiO (36% CaO, 1750°), and CoO (36% CaO, 1420°). The melting-point diagram of mixtures of CaO and TiO_2 shows maxima at $CaOTiO_2$, $2CaOTiO_2$, and $3CaOTiO_2$ and eutectics at 12% CaO, 1420°, and 52% CaO, 1780°. (*T.C.S.E.*)

Molten region in the system aluminum–aluminum oxide–aluminum carbide. EMIL BAUR AND ROLAND BRUNNER. *Z. Elektrochem.*, **40** [3], 154–58 (1934).—Determinations of melting points in the three limiting systems Al–Al_2O_3, Al_2O_3–Al_3C_4 + Al–Al_4C_3, and Al–Al_2O_3–Al_4C_3 were made. Binary phases having the compositions Al_3O_3 and Al_3C_3 and a ternary solid phase were found to exist in the system. The data are applied to the thermal reduction of Al_2O_3. E.J.V.

Progress report on hot-patching cements. A. J. DALE AND V. HACKNEY. *Trans. Inst. Gas Engrs.*, **79**, 240–53 (1929–30). (*C.A.*)

Rapid method for determining the specific heat and thermal conductivity of insulating materials. PIERRE VERNOT. *Chim. & ind.* [Special No.], **31** [4 bis], 269–70 (1934).—Details are given and formulas developed. M.V.K.

Refractories and furnace design. A. F. GREAVES-WALKER. *Blast Fur. Steel Plant*, **22** [1], 49; [2], 124 (1934); reprinted from *Ceram. Age*, **22** [6], 171 (1933). E.J.V.

Refractories for kiln construction. R. J. MONTGOMERY. *Jour. Can. Ceram. Soc.*, **3**, 18–21 (1934).—The use of refractories in kiln construction in Ontario plants is discussed. J.G.P.

Refractory hydraulic concrete and cement. J. ARNOULD. *Chaleur & Ind.*, **9**, 536 (1928).—Whereas natural and ordinary artificial Portland cements disintegrate at temperatures in excess of 500°C, and aluminous cements, such as *ciment fondu*, shrink, crack, and finally melt at about 1400°C, Kestner cement commences to soften only at 1400°C and melts at about 1500°C; its coefficient of expansion is 5.3×10^{-6} and its density 1.5 to 1.8. With broken silica brick or alumina as aggregate it produces an excellent refractory concrete. E. RENGADE. *Ibid.*, **10**, 44 (1929).—R. denies Arnould's contention that aluminous cements are not satisfactory for use at high temperatures and asserts that if properly mixed with suitable aggregates they yield good refractory concrete. J. ARNOULD. *Ibid.*, **10**, 155 (1929).—A. replies to Rengade. (*J.I.M.*)

Significance of refractory materials in the iron and steel industries. A. T. GREEN. *Proc. Cleveland Inst. Engrs.*, No. 6, pp. 173–266 (1931–32).—The first part is devoted to a discussion of the texture and constitution of fireclay, siliceous, and silica products. The structural stability of silica and fireclay products is also dealt with. In the second part, G. discusses features of the design and application of the open-hearth furnace, silica brick in relation to open-hearth furnaces, nature of the brick in use, corrosion and erosion of open-hearth silica brick, general mechanism of corrosion and erosion, casting of steel in relation to the refractories used, selection of refractories for regenerators, and the storage of refractories. (*J.I.S.I.*)

Silicon carbide. JUANA CORTELEZZI AND ROBERT SCHROEDER. *Centr. Mineral. Geol.*, **A**, 123–28 (1934). (*C.A.*)

Studies on heat-resisting substances. I. Properties and uses of mullite heat-resisting materials. H. SEKI, M. KOIZUMI, AND K. TOYOTA. *Repts. Imp. Ind. Research Inst. Osaka, Japan*, **14** [3], 1–32 (1933).—Mullite brick made in an electric furnace show needle crystals. Hardness is more than 8 in Mohs' scale. Fusion point is above cone 36. Specific gravity is greater than that of clay brick. They show greater resistance to pressure and weight when cold or hot. Coefficient of thermal expansion is less than that of clay brick while heat conductivity is greater. Although resistance to sudden heating or chilling is small, they can be used in glass furnaces. They are more resistant to basic than to acid slags. Mullite brick specially made for use in marine vessels have a specific gravity 10% less than clay brick. (*C.A.*)

Super-refractory insulation alters furnace design. E. C. LLOYD. *Steel*, **94** [23], 43–44 (1934).—Superinsulating brick placed inside a steel-encased furnace structure braced with steel shapes give a better overall performance than the old massive masonry construction. The heat flow through the 9-in. superinsulating brick wall is about the same as the flow through a wall of 13.5 in. of fire brick and 4.5 in. of insulating brick. The heat capacity is reduced to $^1/_6$ to $^1/_{10}$ of the heat capacity of the wall formerly used. For furnaces where quick reaction to temperature changes is desired, the low heat capacity of the superinsulating brick is advantageous. M.V.K.

Surface flaking of vertical retorts. A. J. DALE AND V. HACKNEY. *Trans. Inst. Gas. Engrs.*, **79**, 237–38, 245–53 (1929–30). (*C.A.*)

Testing of and specification for glasshouse pot clays. J. H. PARTRIDGE. Presented at meeting of Society of Glass Technology, Stourbridge, March, 1934.—Causes of

failure of glassmelting pots are enumerated and methods are described for assessing the resistance of specimens made from different mixtures to various forces tending to cause failure. The behavior of pots in service is correlated with the results of laboratory tests, enabling a specification to be compiled, based on certain physical properties of the clay rather than on its chemical composition. New apparatus for determining the limiting creep strength of the clays is described. It is shown that the limiting creep strength at high temperatures is affected most markedly by an increase in temperature and by the presence of certain impurities in the clays.

Thermal expansion of artificial graphite and carbon. PETER HIDNERT. Price 5¢ from Supt. of Documents, Washington, D.C. *Bur. Stand. Jour. Research*, **13** [1], 37–51 (1934); R.P. 693.—The linear expansion of longitudinal sections cut from 14-, 3-, $1^1/_4$-, and 1-in. artificial graphite electrodes and of transverse sections cut from 14- and 3-in. electrodes was investigated at various temperatures between 20 and 1000°C. The coefficients of expansion of the longitudinal and transverse sections of graphite increase with temperature. The coefficients of expansion of the transverse sections are larger than those for the longitudinal sections. There appears to be a tendency for the coefficients of expansion of a longitudinal section to increase with increase in the diameter of the graphite electrode from which the longitudinal section has been cut. The longitudinal and transverse sections of graphite indicate changes in length after heating to elevated temperatures and cooling to room temperature. Lesser changes are noted on second heating and cooling. The grain sizes of the different sized electrodes appear to have an effect on expansion. The coefficients of expansion of carbon made with lampblack are about three times as large as the coefficients of carbon made with petroleum coke. R.A.H.

Thermally resistant mixes for electrothermal purposes. M. BUIKHOVSKIĬ. *Keram. i Steklo*, **10** [4], 27–29 (1934).—A discussion of the composition of mixes used for electrothermal purposes and the effect of some of their components is given. Thermally resistant grog mixes consisting of 40% plastic clay, 40% grog, and 20% talc have been developed in U.S.S.R. Details as to their properties are given. M.V.K.

Wet method for preparing sagger mixes. I. P. ROMANKEVICH AND R. B. ANGENITZKAYA. *Keram. i Steklo*, **10** [5], 10–13 (1934).—The wet method for producing sagger mixes has great advantages over the dry method. Humus was found to be the best electrolyte for obtaining mixes of the necessary humidity. The same results are obtained when introducing brown coal and NaOH into the slip. The presence of brown coal improves the thermal stability of the saggers. The suitability and amount of electrolyte depend on the nature of clay used. Clays of high plasticity may be used after firing to 350° for 2 or 3 hr. Diatomite was found to be the best adsorbing medium. M.V.K.

X-ray investigation of the quality of fireclay brick. M. SHAPIRO AND YU. KURDINOVSKIĬ. *Stal*, **3** [9], 77–81 (1933).—The mullite content of fireclay brick can be determined to within 5% by X-ray analysis. Bibliography. (*C.A.*)

BULLETINS

Action of gas atmospheres on refractory materials. S. M. PHELPS. *Amer. Refrac. Inst., Tech. Bull.*, No. 48, 11 pp. (1934).—P. gives a résumé of the work of the Institute on the effects of atmospheres of sulfur dioxide, oxygen, natural gas, hydrogen, water-vapor, carbon dioxide, carbon monoxide, chlorine, hydrochloric acid gas, and regular furnace atmosphere on magnesite, chrome, diaspore, low-iron clay, high-iron clay, and silica refractories. Two selected bibliographies are included: (1) the effect of gas atmospheres on refractories, and (2) disintegration of clay refractories in blast furnaces. Illustrated. W.E.R.

Can refractory raw materials be beneficiated? J. D. SULLIVAN AND B. M. BIRD. *Amer. Refrac. Inst., Tech. Bull.*, No. 50, 11 pp. (1934).—Refractory manufacturers may find it necessary in the future to beneficiate some of their raw materials to produce the kind of products demanded by industry. The procedure for testing ceramic materials to determine the amenability of them to various methods of beneficiation is outlined; the method of making float-and-sink tests and of interpreting the data is given. Illustrated. W.E.R.

Glossary of terms relating to silica and fireclay refractories. JOHN G. STEIN & CO., LTD. *Refrac. Bull.*, No. 1 (Jan., 1932).—Definitions, explanations, and derivations of some of the common terms are given. M.V.K.

Mullite. JOHN G. STEIN & CO., LTD. *Refrac. Bull.*, No. 20 (Aug., 1933).—Mullite, $3Al_2O_3\,2SiO_2$, is the aluminous constituent of fire brick. A high-mullite content increases refractoriness, refractoriness under load, and resistance to corrosion; it also insures a smoother temperature-expansion curve. Other important features of mullite are given. M.V.K.

Progress in refractory practice. JOHN G. STEIN & CO., LTD. *Refrac. Bull.*, No. 24 (Dec., 1933).—The establishment of sound firebrick practice demands the continuous collection of facts so that the maker advances in the understanding of his products and the user realizes the nature of the limits he can impose on the various materials he uses. M.V.K.

Refractories of special shapes. JOHN G. STEIN & CO., LTD. *Refrac. Bull.*, No. 9 (Sept., 1932).—If specially shaped refractories are to be used, better and cheaper service will be obtained with simpler shapes. The shapes may vary greatly in size and where possible should be in multiples of 3 or $4^1/_2$ in. to fit standard brick. Since special shapes are usually molded by hand and are therefore less dense than machine-pressed shapes, they tend to show some after-contraction, deformation under load, and more slagging than pressed brick. In an irregular shape, the mass effect tends to cause differential contraction and vitrification, the thinner portion of the piece tending to contract first and to be harder fired than the thicker. Other difficulties in manufacturing special shapes are mentioned. M.V.K.

Refractoriness. JOHN G. STEIN & CO., LTD. *Refrac. Bull.*, No. 2 (Feb., 1932).—Definition and discussion of refractoriness and an explanation of the Seger cone system for determining refractoriness are presented. M.V.K.

Refractory cements. JOHN G. STEIN & CO., LTD. *Refrac. Bull.*, No. 8 (Aug., 1932).—Requirements, properties, and types of refractory cements used in the jointing of furnace brickwork are given. M.V.K.

Silica, slags, and slagging. JOHN G. STEIN & CO., LTD. *Refrac. Bull.*, No. 17 (May, 1933); for abstract see *Ceram. Abs.*, **13** [4], 92 (1934). M.V.K.

Slagging of a fire brick. II. JOHN G. STEIN & CO., LTD. *Refrac. Bull.*, No. 22 (Oct., 1933).—The chemical action of slag on fire brick and the mechanical removal of the reaction products are explained. For Part I see *Refrac. Bull.*, No. 13, *Ceram. Abs.*, **12** [5], 195 (1933). M.V.K.

Specifications for refractories. JOHN G. STEIN & CO., LTD. *Refrac. Bull.*, No. 14 (Feb., 1933).—The problem of defining a refractory for a given service is full of pitfalls. Usually if one property is overstressed some weakness may appear in another direction; moreover, the formulation of specifications demands a study of statistics and sampling as well as the adoption of simple, straightforward, testing methods which are above doubt. Specifications for refractories are grouped under three headings: (1) constructional or engineering: size and shape, strength (crushing), porosity (true and apparent), permeability, and texture; (2) high temperature: refractoriness, refractoriness under load, after-contraction, thermal expansion, spalling resistance, thermal properties (thermal conductivity and specific heat), and slagging resistance; and (3) chemical: composition, including major and minor constituents. M.V.K.

Study of a group of typical spinels. C. W. PARMELEE, A. E. BADGER, AND G. A. BALLAM. *Univ. of Ill. Eng. Expt. Sta. Bull.*, No. 248 (1932).—In many metallurgical processes which require refractories with exceptional qualities, advantage is taken of the resistance which spinels offer to the attack of acids, alkalis, and ordinary fusion agents as well as their high melting points. The authors have made a study of a representative group of spinels which included the aluminates, chromites, and ferrites of zinc, magnesium, iron, and manganese. Data are presented of such properties of the synthetic spinels as the densities, lattice dimensions, thermal expansions, and specific heats. (*J.I.S.I.*)

PATENTS

Alumina. JEAN C. SÉAILLES. Fr. 759,012, Jan. 27, 1934. Al_2O_3 is made by diluting a Ca aluminate in water and precipitating Al_2O_3 or Al_2O_3 and CaO by an appropriate reagent. (*C.A.*)

Brick lining for rotating furnaces. E. D. PEVZNER. Russ. 33,847, Dec. 31, 1933. Clinker brick high in CaO are used with coarse-grain Portland cement as a binder. (*C.A.*)

Ceramic materials. GENERAL CERAMICS CO. Fr. 752,-998, Oct. 4, 1933. The compactness of ceramic materials and materials which may be worked by processes used in ceramics, such as metals or metal carbides, is increased by eliminating air or gases contained in the primary materials by known means. (*C.A.*)

Ceramic products. PORZELLANFABRIK KAHLA (Werner Rath, inventor). Ger. 591,090, Jan. 16, 1934. Brucite or nemalite is used in the manufacture of ceramic products of high MgO content. The powdered mineral alone may be molded and fired, or products of a spinel character may be prepared from a mixture of the mineral and Al_2O_3, or a eutectic mixture of the mineral and Al_2O_3 may be used as a binder for other refractory materials. Known compositions containing steatite may be modified by using brucite or nemalite in place of a part of the steatite. (*C.A.*)

Fire wall. MICHAEL LIPTAK. U. S. 1,966,674, July 17, 1934.

Fireproof bodies. TURE R. HAGLUND. Ger. 579,536, June 27, 1933. Fused masses containing at least 50% Al_2O_3 or MgO and oxides which do not form spinel, *e.g.*, SiO_2, CaO, etc., are molded; the amounts are adjusted so that 8 to 30% of the product is a compound of a melting point 100 to 500° below that of spinel. (*C.A.*)

Fireproof stone. ARTHUR SPRENGER. Ger. 565,889, Nov. 30, 1927. Stone highly resistant to fire is prepared by fusing oxides of Mg, Cr, Al, and Si at high temperatures, adding finely ground Cr ore or magnesite or both, together with organic or inorganic binding agents, molding, and firing. (*C.A.*)

Furnace wall. F. B. BIGELOW (Bigelow-Liptak Corp.). U. S. 1,967,281, July 24, 1934.

Furnaces. "OFAG" OFENBAU A.-G. Ger. 595,365, April 11, 1934. Details are given of a method of mounting heat-insulating members on hollow water-cooled furnace parts, *e.g.*, furnace conveyer rollers. (*C.A.*)

Manufacture of highly refractory products. EUGEN RISHKEVICH (Deutsche Gold & Silber Scheideanstalt vorm. Roessler). U. S. 1,969,099, Aug. 7, 1934. Improvement in the manufacture of highly refractory products consists in admixing beryllium oxide in amounts of 0.5 to 2.0% to a mixture containing zirconia as main constituent and up to 5% magnesia.

Mullite. DEUTSCHE TON- & STEINZEUG-WERKE A.-G. Ger. 589,556, Dec. 9, 1933. Ceramic material rich in mullite is prepared by firing a mixture of silicates of the sillimanite group and aqueous solutions of Al salts, preferably those containing SO_3 and Cl ions. (*C.A.*)

Porous refractory material and method of making. GAMES SLAYTER (Owens-Illinois Glass Co.). U. S. 1,967,-375, July 24, 1934. The method comprises producing a molten mass of vitreous material, permeating the mass with a highly refractory material in powdered form, removing the surrounding air pressure from the mass, causing the latter to be expanded to an increased bulk by the expansive action of the gases which permeate the mass, and then cooling and hardening the mass.

Refractory bodies. ARTHUR SPRENGER. Ger. 590,357, Dec. 30, 1933; addition to 565,889, "Fireproof stone," above. Fireproof bodies are made by using small amounts of finely divided Cr ores as binding agent for granular masses of MgO, Al_2O_3, and small amounts of SiO_2, TiO_2, Fe_2O_3, etc. See also "Refractory masses," *Ceram. Abs.*, **13** [8], 214 (1934). (*C.A.*)

Refractory brick, etc. FELDMÜHLE, PAPIER- UND ZELLSTOFFWERKE A.-G., FRIEDRICH KLEIN, AND KARL BECHTEL. Ger. 589,500, Dec. 8, 1933; addition to 588,-805, *Ceram. Abs.*, **13** [8], 213–14 (1934). In making fire-

proof brick, etc., by the method of 588,305, the fused oxides are given an addition of gas- or vapor-forming substances shortly before cooling. (*C.A.*)

Refractory brick. HEINRICH KOPPERS A.-G. Ger. 593,254, Feb. 23, 1934. Dry binding clay is mixed with granular refractory material, *e.g.*, chamotte, which has been moistened with water containing a dispersing agent for the clay. The mixture is then molded and fired in known manner. (*C.A.*)

Refractory composition. HERMANN WOLFF. Austrian 136,865, March 26, 1934. Loamy sand is mixed with cement to produce a composition suitable for lining cupola furnaces, etc. (*C.A.*)

Refractory compositions. TURE R. HAGLUND. Ger. 593,498, March 2, 1934. Refractory products are obtained by fusing MgO with a spinel-forming oxide, *e.g.*, Al_2O_3 or Cr_2O_3, and another oxide, *e.g.*, SiO_2, TiO_2, or CaO, in such proportions that the solidified products contain more than 50% of crystallized MgO spinel and at least 8% of compounds of lower melting point than the spinel, *e.g.*, silicates, titanates, or Ca aluminates. The proportion of MgO + CaO in the compounds of lower melting point must be less than 20% or more than 45%. A suitable initial mixture contains MgO 33, Al_2O_3 61, and SiO_2 6%. The fused mixture may be cast into brick, etc., which may be tempered by heating for at least 5 hr. to 1000 to 1500°. (*C.A.*)

Refractory insulating material. ALEXANDER MACKENZIE. Australia 10,857/33, June 29, 1933. The material is made from granulated or finely divided vitrified china clay, *e.g.*, porcelain, admixed with finely divided kaolin bound together by Na_2SiO_3 or other binding agent. (*C.A.*)

Refractory lining in the combustion chamber of a surface-combustion furnace. M. F. MOROZOV. Russ. 28,630, June 30, 1933. The lining is made of asbestos netting placed in one or a number of horizontal layers, the ends of the asbestos cords being inserted in the brickwork. (*C.A.*)

Refractory materials. "ALTERRA" A.-G. Fr. 760,490, Feb. 23, 1934. Calcined MgO for making refractory materials is improved by adding as flux to the crude material poor in CaO and poor in or free from SiO_2, Fe_2O_3, and CaO in amount to form the compound CaO Fe_2O_3, or less CaO than this proportion may be used. See also Brit. 399,126, *Ceram. Abs.*, **13** [1], 16 (1934). (*C.A.*)

Refractory materials. DIDIER-WERKE A.-G. Ger. 594,000, March 9, 1934. Fireproof, porous, insulating stone or chamotte is produced by intimately mixing refractory clay with sawdust and water to form a plastic mass. This is then molded, dried, and fired. Ground clay of granular dimensions of 0 to 0.5 mm. and sawdust of dimensions 0 to 3 mm. are used. (*C.A.*)

Refractory materials. JENNY POHL. Ger. 591,154, Jan. 17, 1934. Refractory substances such as clay, magnesite, dolomite, and Al_2O_3 are heated to softening temperature and then passed directly to a system of pressure rolls. The rolled products may be reheated to softening temperature if desired. Dense products suitable for making refractory articles are obtained. (*C.A.*)

Terra Cotta

Acid-stable stone linings. L. KÖGEL. *Chem. Fabrik*, **7** [9–10], 77–82 (1934).—A discussion is given of (1) requirements for acid-stable plates, (2) their properties, (3) composition of plates and cements used, (4) manufacture, (5) methods of coating, and (6) field of application. Illustrated. M.V.K.

PATENTS

Tile roof. H. D. BROWN. U. S. 1,967,764, July 24, 1934.

Vitrified product. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY, ET CIREY. Fr. 752,636, Sept. 27, 1933. A material of low density having insulating properties toward heat and sound is made by fusing vitrifiable materials containing boric acid and a carbonaceous substance, and carrying the fused mass to the neighborhood of its softening point, preferably after solidification. Thus, a glass formed of sand 100, borax 94, ZnO 97, hydrated Al_2O_3 5, and charcoal 8, gives on heating to 600° a product of apparent density of 1.68. (*C.A.*)

White Wares

Bathroom unit combines shower, lavatory, and table. LAVASHOWER CORPORATION. *Ceram. Ind.*, **23** [2], 63 (1934).—Another departure from the standard bathtub is the new combination of tub, shower, dressing table, lavatory, and towel cabinet made of cast iron and porcelain enamel, in white and standard colors for right- or left-hand recessed installation or with the lavatory end finished for corner installation. The unit is 7 ft. long. Illustrated. E.J.V.

Casting slip. EDWARD SCHRAMM AND F. P. HALL. *Jour. Amer. Ceram. Soc.*, **17** [9], 262–67 (1934).

Durability of tableware decorations. C. J. KOENIG AND A. S. WATTS. *Jour. Amer. Ceram. Soc.*, **17** [9], 259–62 (1934).

Effect of grinding fineness of mixes on properties of high-tension porcelain. A. N. EGOROV. *Keram. i Steklo*, **10** [1], 35–37 (1934).—When preparing mixes for high-tension porcelain, the stony materials should be finely ground; this promotes (1) decrease of the vitrification temperature and (2) increase of mechanical (except resistance to pressure) and electrical strength. The best results are obtained with finely ground quartz passed through a 10,000/sq. cm. sieve and feldspar sifted through a 4900/sq. cm. sieve. Quartz and feldspar should be ground separately. M.V.K.

Effects of variety of flint used on properties of a hotel china. C. L. THOMPSON. *Jour. Amer. Ceram. Soc.*, **17** [9], 268–71 (1934).

Improved method for casting faience sanitary ware. B. I. VISHNEVSKIĬ AND K. N. SHCHERBAKOV. *Keram. i Steklo*, **10** [5], 20–22 (1934).—Details of a contrivance for improving the quality of cast faience sanitary ware are given. Illustrated. M.V.K.

Insulating material of the steatite group. E. ALBERS-SCHONBERG. *Electrotech. Z.*, **54**, 547 (1933).—By steatite is understood those ceramic materials which contain talc as their principal ingredient. Soapstone or dense talc is the mineral product chiefly used. The properties of the more important steatite mixtures are discussed and it is shown how these properties have led to its wide use for low loss dielectrics, high electrical resistance at high temperatures, and high mechanical strength in such articles as line insulators and spark plugs. It can be manufactured to exact dimensional specifications. See also *Ceram. Abs.*, **13** [5], 121 (1934). J.T.L.

Master clay. S. R. HIND. *Pottery Gaz.*, **59** [686], 960–62 (1934).—In giving indications as to the trend in the advancement of technique in the pottery industry, H. discusses clay and its impurities, how purification is obtained, difficulties with ball clay, why potters' clay is "slipped," and new researches and results; he showed that pottery production is a perfectly balanced operation. Opportunities for specialists are pointed out. The changes taking place in pottery during firing are briefly summarized. The relation of art to technique is a primary consideration in pottery production. E.J.V.

Meeting foreign competition and making money. ANON. *Ceram. Ind.*, **23** [2], 71 (1934).—The W. S. George Pottery Co., East Palestine, Ohio, decided to meet the competition of an Italian ware coated with a heavy mat glaze, improperly prepared and applied, with a rustic and aged appearance by producing a better quality ware which resembled the imported product. A mat glaze was developed, similar to the Italian ware in appearance, but of a much higher firing and with more durable, richer coloring and more even distribution over the piece. It was found possible to undersell the foreign product with profit. Illustrated. E.J.V.

Minutes of meetings of Industrial Advisory Committee on Whiteware to the Bureau of Standards. R. F. GELLER. *Bull. Amer. Ceram. Soc.*, **13** [8], 212–13 (1934).

Porcelain and related ceramic insulating materials. W. WEIRCKER. *Electrotech. Z.*, **54**, 543 (1933).—The general details of the fabrication of porcelain insulators are described. Besides the control of the manufacturing processes, development of new compositions has in recent years added to the effectiveness of the material. Special bodies are developed for high frequency insulation where low power loss is essential. J.T.L.

Porous diatomite mixes. I. Z. RAICHLIN. *Keram. i Steklo*, **10** [4], 21–24 (1934).—Details of experiments made with various diatomite mixes for use as filters for drinking water are given. M.V.K.

Rapid firing of spark-plug porcelain. C. F. GREENE. *Ceram. Ind.*, **23** [2], 72–77 (1934).—This investigation was conducted on an open-fire, rapid-fire tunnel kiln firing spark-plug insulators in $1^1/_2$-in. deep open saggers to 1300°C on a 15-hr. cycle. Automatic temperature control was used which confined maximum temperature fluctuation in the firing zone to about 3°C. Tests varying the rate of preheating above 600°C showed that it was possible to reduce the loss from cracked porcelain; gas consumption was also lowered. Tests showed that with 3-in. saggers a great reduction of cracking loss and more uniformity in specific gravity were obtained. Changes in the composition of the fuel gas cause variation in (*a*) specific gravity, (*b*) ultimate CO_2, (*c*) volume of products of combustion, (*d*) available B.t.u. per cubic foot of gas, (*e*) rate of flame propagation, and (*f*) theoretical flame temperature. A dual, metallic, chamber-type recuperator applied to the kiln realized an actual average saving of 4% in fuel. Interesting results were obtained on the same rapid-fire kiln with coal gas, commercial butane, and fuel oil. Classes of ware successfully fired in this type kiln included spark-plug porcelain, low-tension porcelain shapes formed by both wet (casting) and dry-press process, and faience and tile. E.J.V.

Working conditions of gypsum molds. A. I. AVGUSTINIK AND P. M. BRUSLINSKAYA. *Keram. i Steklo*, **10** [4], 29–32 (1934).—The process of absorption of moisture from the ware by gypsum molds can be characterized by the function of the type: $Q = f(W_1T)$. The temperature increase of the mold lowers the rate of water absorption and the absolute amount of moisture. The increase of moisture content of the mass tends to increase the amount of moisture absorbed by gypsum. Ware in gypsum molds should be dried at 15 or 20°. Drying time for porcelain insulators is about 1 hr. The moisture content of the gypsum mold tends to lower the water absorption. Gypsum molds should not be used more than 10 times consecutively for drying insulators without predrying them. M.V.K.

PATENTS

Binder for pressing chinaware. N. A. MASLYANSKIĬ. Russ. 33,626, Dec. 31, 1933. Instead of tar as a binder in pressing chinaware, anhydrous light petroleum bottom oils or spindle oil is used mixed with turpentine, wood tar, or drying oil; the mass is heated to 50 to 60° until it acquires a homogeneous appearance. (*C.A.*)

Bushing insulator. A. O. AUSTIN (Ohio Brass Co.). U. S. 1,967,653, July 24, 1934.

Ceramic articles that can be fired at low temperature. GÉZA BECKER. Hung. 107,181, Sept. 1, 1933. Steatite is added to the raw material in quantities from 20 to 90%. Articles thus obtained can be fired at low temperature and are resistant to rapid variations of temperature. (*C.A.*)

Closet bowl and method of flushing. GEORGE BRAIN (Standard Sanitary Mfg. Co.). U. S. 1,966,786, July 17, 1934.

Electric insulating material. JOSEF EFFENBERGER. Ger. 594,080, March 10, 1934. A wet mixture of kieselguhr with 10 to 60% of clay or kaolin is molded, air-dried, and heated to 400 to 1000°. The product may then be dipped while still warm in a clay slip and reheated to 500 to 1600°, or it may be comminuted, mixed with 10 to 60% of clay or kaolin, moistened, molded, and heated to 500 to 1600°. The final products do not become conductive at high temperatures and may be used for lining electric furnaces. (*C.A.*)

Insulator. A. O. AUSTIN (Ohio Brass Co.). U. S. 1,967,654, July 24, 1934. W. A. HILLEBRAND (Ohio Brass Co.). U. S. 1,967,616, July 24, 1934.

Spark plug and method of making. O. C. ROHDE (Champion Spark Plug Co.). U. S. 1,968,314, July 31, 1934. In making a spark plug, the method consists in placing a metal shell around a nonvitreous insulating tube surrounding an electrode.

Water-closet construction. J. N. MURPHY (August F. Maurer). U. S. 1,967,680, July 24, 1934.

Equipment and Apparatus

Automatic control in California cement plant. J. B. HUTTL. *Eng. Mining Jour.*, **135** [6], 265–67 (1934).—Sequence control of motors employed throughout allows automatic starting or stopping of motors in any desired sequence. Drawings show the wiring of the automatic drier feed, the automatic mill feed on the two Hardinge raw mills, the wiring of an automatic mill feed, and the arrangement for feeding raw materials to the kilns. J.L.G.

Color filters for altering color temperature. Pyrometer absorption and daylight glasses. H. P. GAGE. *Jour. Opt. Soc. Amer.*, **23** [2], 46–54 (1933).—Color filters that will reduce or increase the color temperature of a complete radiator although reducing its brightness are defined by an analysis of the Wien equation. With a given filter the change in reciprocal color temperature is proportional to the thickness of the glass color filter used. A table gives the color temperature of some artificial light sources and their reciprocals and the equivalent temperature with its reciprocal for various phases of daylight expressed according to the Planck and the Wien equations. R.H.H.P., JR.

Combustion equipment. VERNON WALKER. *Elec. Rev.*, **115** [2955], 52 (1934).—W. briefly reviews American practice for stoker boiler firing mentioning admission of secondary air, use of baffles, stoppage of coal supply, and banking and corrosion. J.L.G.

Construction and use of a Pfund parallel-plate refractometer. M. ALDEN COUNTRYMAN AND WILLIAM KUNERTH. *Jour. Opt. Soc. Amer.*, **24** [1], 25–28 (1934).—A rapid method of determining, by means of a Pfund parallel-plate refractometer, the time rate of change of the index of refraction of liquids within a range up to 1.523 with an accuracy of 0.5% is described. R.H.H.P., JR.

Conversion of photographic sensitiveness scales. J. A. M. VAN LIEMPT. *Rec. trav. chim.*, **53** [6], 816–17 (1934).—For the three scales of sensitivity at present chiefly applied, *i.e.*, the Scheiner (Sch), the Hurter and Driffield (HD), and the German DIN system, conversion formulas have been developed: °Sch = 10 log HD − 7.7, and °DIN = 10 log HD − 17.7. M.H.

Cooling large enclosed motors. J. V. HUNT. *Factory Management & Maintenance*, **92** [7], 315–16 (1934).—Totally inclosed motors as large as 3 to 5 h.p. can be constructed without provision for ventilation. Larger powers can be made much smaller in size than normal if ventilated by a fan. Fan-cooled motors and explosion-resisting motors are considered. Illustrated. J.L.G.

Determination of particle-size distribution in mineral powders by air elutriation. R. N. TRAXLER AND L. A. H. BAUM. *Rock Prod.*, **37** [6], 44–47 (1934).—The determination of particle-size distribution in powders used as fillers is important because the void content and the size of the individual voids in the compacted powder decrease as the particle-size heterogeneity increases. A method and apparatus for determining particle-size distribution in mineral powders by air elutriation is described in detail, and the method of presenting the experimental results is briefly discussed. Data are given for several commercial powders. Illustrated. E.J.V.

Development of quiet propeller fans. K. D. MCMAHAN. *Gen. Elec. Rev.*, **37** [2], 82–86 (1934).—Illustrated. R.H.H.P., JR.

Electric resistance materials. ALFRED SCHULZE. *Metallwirtschaft*, **13** [21], 369–72 (1934).—Alloys for resistance materials consist mainly of metals with high melting point and which form solid solutions, such as Cu, Ni, Fe, Cr, or Mn. The temperature coefficient of the resistance which is of great practical importance is generally the smaller, the higher the resistance is at room temperature. The particular requirements for precision and commercial resistors are discussed, and properties of Cu alloys, Cr-Ni alloys, Cr-Fe alloys, and others in different compositions are given in charts and tables. The material at present available for highest temperatures is the Kanthal alloy with a melting point at 1600°C; it can be used at 1350°C (2460°F) continuously and consists of Fe, Cr, Al, and Co. Specific resistance is 1.45 ohm/mm.²/in. at 20°C, 1.54 ohm at 1000°C, and 1.57 at 1300°C. M.H.

Electrical lubrication of stiff-mud dies. J. O. EVERHART. *Jour. Amer. Ceram. Soc.*, **17** [9], 272–79 (1934).

Electrical precipitation of silica dust. W. R. FRANKS AND F. L. HARRISON. *Trans. Roy. Soc. Can.*, **27** [5], 141–47 (1933); abstracted in *Ind. Hyg. Abs.*, **16** [4], 85 (1934).—The presence of moisture or sulfur dioxide does not decrease the electrostatic precipitation of silica dust. The use of this method of dust precipitation is suggested for clearing dust from air in mine drifts. E.J.V.

Endurance testing machine for determining fatigue strength of samples and structural elements. H. OSCHATZ. *Metallwirtschaft*, **13** [25], 443–48 (1934).—The present tendency in testing materials is the application of dynamic testing methods not only on standard samples but on structural elements as they are used in practical cases. The dynamic test includes (1) notch effect and notch sensitiveness, (2) effect of surface condition, and (3) pre-imposed stress, as these conditions are of foremost importance for the endurance behavior or fatigue strength of a material. A testing machine is described which was developed especially for testing structural elements of different shapes under practical conditions and at low and elevated temperatures. M.H.

Experiments with impact testing apparatus by compressed air. H. PRESSER AND E. SCHLOBACH. *Glückauf*, **70** [22], 497–504 (1934).—The various types of impact testing apparatus operated by compressed air do not give

results which can be compared directly. An instrument with a spring for the impact action has been developed which is recommended both for measurements and especially for calibrating compressed air instruments. It is useful for tests in mining and for metallurgical and nonmetallic specimens and is described in detail. M.H.

Formula and tables for the pressure of saturated water-vapor in the range 0 to 374°C. NATHAN S. OSBORNE AND CYRIL H. MEYERS. 5¢ from Supt. of Documents, Washington, D.C. *Bur. Stand. Jour. Research*, **13** [1], 1–20 (1934).—A formulation has been developed which by a single equation represents an adjusted composite appraisal of the available data and defines concisely and explicitly the relation of saturation pressure to temperature between the freezing point and the critical regions. Comprehensive tables of pressure, derivatives, and boiling points are given. R.A.H.

Grinding plant research. IX. New surface produced by grinding. WILLIAM GILBERT. *Rock Prod.*, **37** [6], 31–33 (1934).—The new surface produced by crushing or grinding is proportional to the energy expended, and the work done is proportional to the area sheared, according to Rittinger's law. In applying this law, the surface of a definite weight of material at various stages of the crushing or grinding process must be estimated. The particle surface area of a fine powder may be obtained (*a*) by dividing the sample into a number of grades by sieving, elutriation, or sedimentation, observing the average particle width in each grade by a microscope, and from the average width calculating the particle surface area, and (*b*) by immersing the sample in a suitable acid where the loss of weight per hour is assumed to be proportional to particle surface area. In investigating the new surface produced by grinding standard sand, the sand was ground to a residue of 6.76% on the 180-mesh sieve in an 18-inch experimental mill. The sand passing the 180-mesh sieve was divided into five grades by sedimentation, using Daniel Hall's method, which is described in detail. The range of widths of 500 particles in each grade was measured microscopically in units of 0.0001 in. Each particle is treated as a cube, the measured widths being taken as the length of one side, and from the equivalent cube the surface area in square feet per pound is deduced. The probable error of surface calculations in measurement of particle width depends on the ratio between the three sides and not on the actual dimensions. For Part VIII see *Ceram. Abs.*, **12** [2], 70 (1933). E.J.V.

High-frequency furnaces in the laboratory. G. KROLL. *Aciers spéciaux*, **9** [101], 24–30 (1934).—The two principal types of high-frequency furnaces are described: one is supplied by a generator of low voltage and constant amplitude of the current up to 8000 cycles, and the other by a spark gap which gives high voltages (about 8000 volts) and damped oscillations of about 60,000 cycles. The latter type is said to have a much better efficiency. The generator furnace can operate continuously without adjustment, while the spark-gap furnace requires readjustment of spark-gap and spark electrodes after some time. High-frequency furnaces are particularly suitable for melting in a vacuum or under certain gases; arrangements of furnaces are described. M.H.

Manoviscometer, a new apparatus for measuring viscosity. L. STEINER. *Centr. Zuckerind.*, **40**, 879–80 (1932); *Sugar Abs.* (in *Facts About Sugar*), **28**, 104 (1932).—The viscosity of any liquid at any temperature can be measured in c.g.s. units in the apparatus consisting of a cylinder fitted with a piston by which a definite quantity of liquid can be drawn in and forced out through an opening of standard size in a known time interval. The resulting pressure is measured by a sensitive manometer. Arrangements are provided for heating the liquid. (*C.A.*)

May cost little to save much on power transmission. ROBERT W. DRAKE. *Factory Management & Maintenance*, **92** [7], 317–19 (1934).—Better bearings, wider belts, larger pulleys, and correct tension on belts may save thousands of dollars in power transmission. Illustrated. J.L.G.

"Microhardness" of minerals comprising the Mohs' scale. HAROLD C. HODGE AND J. HAROLD MCKAY. *Amer. Mineralogist*, **19** [4], 161–68 (1934).—Microhardness values for each of the nine minerals from talc to corundum were obtained by using the microcharacter, a standard hardness tester designed for work on bearing metals. A description is included. The microcharacter may be applied to a more complete study of the hardness of minerals. A.K.

Perfection of quartz and other crystals and its relation to surface treatment. R. M. BOZORTH AND F. E. HAWORTH. *Phys. Rev.*, **45** [11], 821–26 (1934).—Results when using an X-ray double-crystal spectrometer indicate that quartz is a perfect crystal and specimens of Rochelle salt, fluorite, and possibly tourmaline and pyrites may be found which can be so classed. Etched quartz crystals are suggested for use in the double-crystal spectrometer because of their high resolving power, about twice that of calcite. J.L.G.

Photoelectric colorimeter. B. LANGE. *Chem. Fabrik*, **7** [5–6], 45–47 (1934).—Through the use of semiconductor photo-cells, the photoelectric measurements are simplified to such an extent that their use is unlimited. Because of the increase of sensitivity, small differences in color may be measured so that the opacity of various water samples can be distinguished. Nontransparent bodies may be investigated photoelectrically when using the reflection measurer. M.V.K.

Photoelectric comparator for rapid measurement of reflection and transmission. CLAYTON H. SHARP AND H. J. ECKWEILER. *Jour. Opt. Soc. Amer.*, **23** [7], 246–50 (1933).—An apparatus for determining reflection and transmission factors either in white light or in various regions of the spectrum is described in which a photoelectric cell is used as an indicator of equality between two beams of radiation. R.H.H.P., JR.

Photoelectric measurements of absorption and changes in color. RUDOLP SWIG AND FRIEDRICH MÜLLER. *Chem. Fabrik*, **7** [3–4], 25–27 (1934).—The application of photoelectric photometry for measuring optical properties of materials and its advantages are discussed in detail. M.V.K.

Producing extremely high temperatures. WILLI M. COHN. *Glass Ind.*, **15** [7], 149–50 (1934).—Investigations at very high temperatures require the solution of a number of interesting problems. Modern means of obtaining ex-

tremely high temperatures in the laboratory are (1) use of an electric arc in connection with two hollow mirrors, (2) tungsten and molybdenum furnaces for work in oxidizing or reducing atmospheres or in the vacuum, and (3) gas-fired zirconium oxide furnaces. Electron bombardment of solids is the most satisfactory method for vacuum work. High-temperature investigations under very pure conditions have been carried out recently using the radiant energy of the sun. These investigations may be carried out in any atmosphere or in the vacuum. Both electron bombardment and the sun furnace make it possible to obtain temperatures limited only by the evaporation of the sample. Other means are mentioned for obtaining high temperatures for short intervals. Illustrated. E.J.V.

Rapid vacuum method for determining porosity. A. N. AVGUSTINIK AND D. I. SMIRNOV. *Keram. i Steklo*, **10** [1], 33–34 (1934).—The method described has great advantages over the boiling and saturation methods giving more exact results and being more rapid (about 30 minutes for several samples). Details as to procedure and apparatus used are given. M.V.K.

Rays from black bodies, rational base of pyrometry. MARCEL BERTHON. *Céram., Verrerie, Émail.*, **2** [1], 7–11 (1934).—B. discusses the laws of radiation from black bodies and shows the relation to practical applications. A pyrometer using a photoelectric cell to measure these radiations is described. M.H.B.

Resistance and radiation of tungsten as a function of temperature. W. E. FORSYTHE AND E. M. WATSON. *Jour. Opt. Soc. Amer.*, **24** [4], 114–18 (1934).—For different temperatures values of the specific resistance, total emissivity, normal brightness, and the total radiation of well-aged very pure tungsten wire have been determined. R.H.H.P.,JR.

Screening: Some problems and essentials. H. J. HUDSON. *Crushing, Grinding, Mining, Quarrying Jour.*, **2**, 161–64 (1934).—Various types of screens and their development are discussed. (*C.A.*)

Small capacity pumps. F. R. LORENZ. *Eng. Progress*, **15** [5], 87–90 (1934).—The structure and characteristics of types of rotary pumps are considered. The design of centrifugal pumps is described and illustrated with special references to low pressure, vertical, deep-well, and self-priming pumps. Rotary vane, geared, and plunger pumps are also considered. Illustrated. J.L.G.

Study of porosity, permeability, and aging. PAUL WALTER. *Chim. & ind.* [Special No.], **31** [4 bis], 213–17 (1934).—The apparatus described permits the study of the porosity and permeability of any bodies, their behavior under the action of various gases or liquids at any pressure and temperature, and their aging. Illustrated. M.V.K.

Thermomechanics of bimetal. T. A. RICH. *Gen. Elec. Rev.*, **37** [2], 102–105 (1934).—An analysis of the bending of bimetal with change in temperature is presented, together with formulas for the calculation of the deflection, curvature, internal stresses, and contact force. Bimetal is most efficiently used as a beam of uniform strength. R.H.H.P.,JR.

Zone-plate determination of dominant wave-length of filtered lamplight. JOSEPH W. ELLIS AND BARTHOLD W. SORGE. *Jour. Opt. Soc. Amer.*, **24** [4], 103–106 (1934).—The dominant wave-length, according to the eye, of lamplight of definite color temperature transmitted through various Wratten filters was determined through the use of the enormous inverted chromatic aberration of a zone plate. R.H.H.P.,JR.

BOOK AND BULLETIN

Temperature-viscosity measurements in the systems CaO–SiO_2 and CaO–SiO_2–CaF_2. C. H. HERTY, JR., F. A. HARTGEN, G. L. FREAR, AND M. B. ROYER. *Bur. Mines Rept. of Invest.*, No. 3232, 31 pp. (1934). Free. Construction and results obtained with the viscometer and apparatus for the determination of viscosity of high melting materials are described. R.A.H.

Thermostats and Temperature Regulating Instruments. ROOSEVELT GRIFFITHS. J. B. Lippincott Co., Philadelphia, Pa. 153 pp. *Heating & Ventilating*, **31** [6], 64 (1934).—The book attempts to cover the entire field of heat control and gives lucid explanations and excellent diagrams of the basic types of thermostats. A short description of relays and control valves is given. E.J.V.

PATENTS

Apparatus for deglazing ceramic articles. PORZELLANFABRIK F. THOMAS. Ger. 596,319, May 2, 1934. (*C.A.*)

Autoclave. ARISTID VON GROSSE. Ger. 595,306, April 10, 1934. Structural features are described. (*C.A.*)

Brickmaking machine. J. R. T. CLINGAN AND P. J. SHEEHAN. U. S. 1,967,608, July 24, 1934.

Ceramic products. ALFRED WANKLIN. Ger. 584,833, Sept. 29, 1933. Apparatus is described for working up, conveying, and firing objects made from a mixture of clay and hot filling material. (*C.A.*)

Combined drying and grinding apparatus for clay, brown coal, gypsum, etc. ERNST C. LOESCHE. Ger. 593,122, Feb. 21, 1934. (*C.A.*)

Drier for dyes, clays, etc. PHILIP W. BUR. Ger. 579,540, June 28, 1933. (*C.A.*)

Filter press with plates of ceramic material. WILHELM SCHULER G.M.B.H. (Ernest Bauder, inventor). Ger. 583,557, Sept. 5, 1933. (*C.A.*)

Fusion apparatus. JEAN MAUCLET. Fr. 761,435, March 19, 1934. The combustion gases and excess air are evacuated to the upper part of the fusion zone by tubulures, etc. (*C.A.*)

Fusion furnace. JEAN MAUCLET. Fr. 761,130, March 12, 1934. Means for regulating the air pressure in the blowers are described. (*C.A.*)

Graphite and tantalum carbide thermocouple for measuring high temperatures. ALLGEMEINE ELEKTRICITÄTS-GES. Ger. 593,022, Feb. 20, 1934. (*C.A.*)

Machine for forming clay products. MAX MUELLER. U. S. 1,969,028, Aug. 7, 1934.

Means for mechanically handling ranks of severed brick, etc., and for loading on wagons for conveying to drying apparatus. H. H. BAILEY AND J. JACKSON. Brit. 413,277, July 25, 1934.

Method of preparing a material for the production of molds for use in manufacturing pottery articles, etc. W. H. GRINDLEY & CO., LTD., AND W. H. GRINDLEY. Brit. 404,367, Jan. 24, 1934.

Mold lubricant for clay products. P. C. LEMMERMAN (Grasselli Chemical Co.). U. S. 1,967,830, July 24, 1934.

In a process of molding clay products the step of wetting or coating the molds with an aqueous solution of a non-acidic salt of a polyvalent, weak acid, the negative ion of which has an ionic weight greater than about 80, is described.

Oils for ceramic presses, etc. KARL JUNGMANN AND "BITUMA" BERGBAU-UND CHEM. IND. A.-G. Ger. 591,339, Jan. 20, 1934. Use is made of mixtures of hydrocarbon oils with (1) liquid resin obtained as a by-product in the cellulose industry, (2) conversion products of the liquid resin, *e.g.*, tall oil, or (3) a sulfonated fat, fatty oil, or fatty acid. (*C.A.*)

Presses for producing brick, tile, etc. C. F. KENNEY. Brit. 413,009, July 18, 1934.

Screening and filtering apparatus. F. W. BRACKETT. U. S. 1,967,050, July 17, 1934. Screening and filtering apparatus in which a number of perforated metal plates are assembled upon chains for driving by suitable means to form a traveling band wherein the plates are formed in sections is described.

Kilns, Furnaces, Fuels, and Combustion

Fuel economy in the ceramic industry. I. FELIX SINGER. *Trans. Ceram. Soc.* [Eng.], **33** [6], 215–27 (1934).—A general survey of the economy of operation of the periodic chamber, annular, zigzag, and tunnel kilns shows that the gas-fired tunnel kiln is superior because of the dependence of the various kiln systems on local conditions and the possibilities of obtaining coal. **II.** *Ibid.*, pp. 228–40.—The heat economy of a ceramic kiln is dependent upon an adjustment of the firing process to the properties of the ceramic body, and savings in coal consumption are possible by the utilization of waste heat, employment of a cheaper fuel, and consumption of less fuel. R.H.H.P., JR.

Further studies of the tunnel kiln. W. D. RICHARDSON. *Jour. Amer. Ceram. Soc.*, **17** [9], 279–82 (1934).

Industrial gas installations. W. BAUSER. *Gas & Wasserfach*, **77** [21], 349–54 (1934).—Gas-fired furnaces for industrial and commercial plants are described, among others a rotating batch furnace, automatic hardening drum furnace, tempering furnace, core-drying furnace, universal annealing furnace, annealing and hardening twin furnace, and gas-fired boiler. Operating data are given. M.H.

Methods for determining the consumption of fuel for industrial furnaces when planning a new furnace. A. A. SHCHUKIN. *Keram. i Steklo*, **10** [3], 27–29 (1934).—A critical examination of various methods is given. The method of determining the thermal balance of a furnace was found to be the most exact and suitable. M.V.K.

Principles of tunnel kiln design for architectural terra cotta. WALTER A. HULL. *Bull. Amer. Ceram. Soc.*, **13** [8], 196–200 (1934).

Proposed gloss firing cycle based upon the temperature of plastic flow of the body. G. A. KIRKENDALE AND R. J. MONTGOMERY. *Jour. Can. Ceram. Soc.*, **3**, 25–28 (1934).—The object of this investigation was the glazing of tile or brick at a low cost, using electric power. The major economy would be effected by heating the glazed piece slowly to a critical temperature and at once transferring it to a hotter zone maintained at the maturing temperature required for the glaze. After holding long enough to mature the glaze the temperature would be suddenly reduced to the critical temperature from which the final cooling would proceed slowly. It was assumed that this critical temperature, which is the lowest temperature that can be used without cracking the body, is related to the temperature of plastic flow of the body. Above this temperature the body will lack rigidity and will successfully withstand a considerable thermal shock without failure. From the experiments conducted in the laboratory it was shown that (1) the proposed gloss cycle, including a sudden temperature from 500 to 1000°C on heating and from 1000 to 500°C on cooling, was successfully carried out in the laboratory on tile 3 x 3 x $^1/_2$ in. in size; (2) the temperature of plastic flow agrees with the temperature of cracking of the tile; (3) further study with a properly designed furnace would be justified as such a gloss cycle would result in considerable saving in time, heat, and cost of kiln construction. J.G.P.

Temperature measurements of flowing gases. ANON. *Glass Ind.*, **15** [7], 154–55 (1934).—To secure true gas temperatures radiation effects in the furnace should be reduced to a negligible quantity. One method is the use of couples of small diameters, as the rate of conduction of heat becomes greater and the radiation loss less when the wire diameter is decreased. By using several thermocouples of varying diameters in a cluster and plotting the indicated temperatures, the true gas temperature can be determined by extrapolating the curve to zero diameter. Another method is the use of a suction couple, in which hot gases are sucked rapidly through a quartz or porcelain tube in which the couple is placed. Data obtained using both methods are presented. Illustrated. E.J.V.

Uniform thermal history. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **13** [8], 193–94 (1934).

What variation in ceramic thermal treatment is allowable and what is unavoidable? EDITORIAL. *Bull. Amer. Ceram. Soc.*, **13** [8], 194–95 (1934).

BOOK REVIEW

Testing Tunnel Kilns of the Ceramic Industry. N. A. MIGULIN. 132 pp. Ukrainian State Pub. House of Light Industry, Kharkov, 1934. Price 2 R 50 kopecks. This is a useful contribution dealing in detail with the subject. After a discussion on the elements of the plan of testing (general description of the kiln, efficiency, fuel expenditure, air for combustion, etc., out-going gases, temperature and pressure distribution in the kiln), M. outlines the basic thermal calculations, such as the heat balance of the kiln, etc. In an appendix are given examples of calculation of two furnaces of the Fougerone and Lengersdorff types and tables for calculation. The volume may be recommended as a good reference book for those interested in tunnel-kiln testing and their thermotechnical calculations. S. I. PERKAL

BOOKS AND BULLETINS

Heat. JAMES M. CORK. xi + 279 pp. John Wiley and Sons, New York. Briefly reviewed in *Nature*, **134** [3375], 8–9 (1934).—An advanced theoretical survey is presented. The two concluding chapters deal with the production of high and of low temperatures. Questions and problems are included. An appendix contains tables of constants and numerical data. J.L.G.

Heat (Matriculation Standard). ROBERT W. HUTCHINSON. vii + 266 pp. University Tutorial Press, London. Price 3s 6d. Briefly reviewed in *Nature*, **134** [3375], 8–9 (1934).—This is an introductory text. J.L.G.

Occurrence of gases in coals. R. F. SELDEN. *Bur. Mines Rept. of Invest.*, No. 3233, 64 pp. (1934). Free. S. reviews recent literature on the occurrence of gas in coals and discusses the present status of the situation critically. R.A.H.

Textbook on Heat. A. W. BARTON. xiii + 378 pp. Longmans, Green & Co., New York. Briefly reviewed in *Nature*, **134** [3375], 8–9 (1934).—This is an intermediate textbook. J.L.G.

PATENTS

Annular kilns. FRIEDRICH MEYER. Ger. 580,693, July 14, 1933. (*C.A.*)

Brick kiln. ALOIS HABLA. Ger. 592,900, Feb. 17, 1934. N. Z. PRIMAKOV. Russ. 32,368, Sept. 30, 1933. Construction details are given. (*C.A.*)

Circular brick kiln. P. P. ANDRIYASHEV. Russ. 33,446, Nov. 30, 1933. Construction details are given. (*C.A.*)

Furnace. S. M. FINN (Drake Non-Clinkering Furnace Block Co., Inc.). U. S. 1,968,934, Aug. 7, 1934. Discharge means for introducing gaseous agents into a furnace comprises refractory blocks having at their abutting faces tapering, spirally fluted channels so arranged that the channels of two abutting blocks form a spirally fluted nozzle.

Furnace regulator. W. E. JOHNSTON. U. S. 1,968,150, July 31, 1934. A regulator for a burner uses oil and air.

Kiln for ceramic ware. FOURS ÉLECTRIQUES BOREL SOC. ANON. Swiss 162,939, Sept. 16, 1933. (*C.A.*)

Kiln for firing clay. EMRIK I. LINDMAN. Ger. 590,724, Jan. 11, 1934. (*C.A.*)

Kiln furniture. E. B. FORSE (Carborundum Co.). U. S. 1,969,126, Aug. 7, 1934.

Retort. H. M. ROBERTSON. U. S. 1,968,775, July 31, 1934.

Smoke consumer for ceramic kilns. FIRMA HERMANN T. PADELT. Ger. 590,725, Jan. 9, 1934. (*C.A.*)

Tunnel kiln with parallel drying channels. ERIKA LENGERSDORFF. Ger. 575,106, Nov. 23, 1933, and 581,995, Nov. 23, 1933. (*C.A.*)

Geology

Crystal structure of diaspore. M. DEFLANDRE. *Bull. soc. franç. minéral.*, **55**, 140–65 (1932).—Diaspore has *a* 4.40, *b* 9.38, *c* 2.83 Å; space-group D_{2h}^{16}. The unit cell contains $2(Al_2O_3 \cdot H_2O)$. (*C.A.*)

Diatomite, its history, characteristics, and uses. J. W. D. GREIG. *Jour. Can. Ceram. Soc.*, **3**, 21–25 (1934). J.G.P.

Diatomite: its rôle in the chemical industry. VICTOR CHARRIN. *Ind. chimique*, **20** [236], 648–49 (1933).—The origin and occurrences of diatomite are described. Its characteristics, which are the basis for its use, are (1) whiteness, (2) texture, including porosity and weight, and (3) elementary composition with the predominance of silica. Chemically it is a neutral material, unattacked by acids and salty solutions with the exception of hydrofluoric acid and alkaline baths. When heated to 800°, its water of crystallization escapes, and the porous silica changes into tridymite or anhydrous massive silica with the disappearance of the alveolar structure. This is completed at 1500°. The impurities present rapidly change the properties of diatomite. The composition of various diatomites is given and its application in industries is briefly discussed. M.V.K.

Experiments on frothed clays. S. R. HIND. *Trans. Inst. Gas Engrs.*, **79**, 228 (1929–30).—China clay and ball clay slips were treated to give a froth (method not given); the froth was dried, fired to 1250°, ground for grog, bonded with 15% ball clay, and refired to 1200°. The thermal conductivity at 267 to 500° was 0.00050, at 415 to 800°, 0.00064, and at 640 to 1100°, 0.00077. (*C.A.*)

Investigations concerning the use of volcanic ash in the field of ceramics. W. G. WORCESTER. *Jour. Can. Ceram. Soc.*, **3**, 48–59 (1934).—Large quantities of volcanic ash exist in western Canada. Ash from Saskatchewan has a relatively low fusion point, a little below that of ordinary feldspar, and it fuses to a glass-like bead. The possibility of utilizing some of these materials for ceramic purposes was therefore investigated. The following conclusions are given as a result of the work carried thus far: (1) Volcanic ash of the type here studied can be used as the entire replacement for feldspar in glazes of the type used in this investigation. (2) Glazes containing the highest amounts of volcanic ash fused at a lower temperature than those containing feldspar, or the glass produced in the ash series was of a lower degree of viscosity. (3) In glazes where copper oxide was used, the color tones were more pleasing than were the feldspar colored glazes. (4) The volcanic ash mat glazes, if applied too heavily, tended to part or bead. (5) There was no greater tendency to crazing in the case of the volcanic ash glazes than with the feldspar glazes, other than in the clear transparent colored glazes where copper oxide was used. (6) Volcanic ash when used as a body flux in the clays selected for investigation did not prove to be as useful or active as feldspar. (7) Larger amounts of volcanic ash or higher temperatures are necessary to produce the equivalent work of feldspar in clays of the type used. (8) The small amount of iron present in the volcanic ash did not alter the fired color or shade of the clays used. This condition would not likely hold true in cases of very light firing bodies. J.G.P.

Researches on the zeolites. J. WYART. *Bull. soc. franç. minéral.*, **56**, 81 (1933).—Zeolites were examined by X-rays, and their lattice structure, crystalline structure, and symmetry group were determined. (*T.C.S.E.*)

Working up iron-containing bauxites. LÁSZLÓ PUT-

NOKY AND BÉLA BOBEST. *Math. naturw. Anz. ungar Akad. Wiss.*, **50**, 497–506 (1933).—$Ca_3(AlO_3)_2$ but no $Ca(AlO_2)_2$ is formed on the working up of bauxites by means of hydrated lime under pressures of 10 to 15 atmospheres at temperatures of 180 to 200°. By treating the bauxite-lime mass with a solution of Na_2CO_3 a precipitate was obtained which could easily be filtered from the alkali aluminate solution. This precipitate consisted of the Fe compounds of the bauxite mixed with so much $CaCO_3$ that no rational metallurgical operation could be found for working up this Fe. Hungarian bauxites required about 3 mol. CaO for working up 1 mol. Al_2O_3. (*C.A.*)

Zoning in plagioclase feldspar. JAMES PHEMISTER. *Mineralog. Mag.*, **23** [145], 541–55 (1934).—P. describes various types of zoning in plagioclase feldspar in the calciferous sandstone basalt lavas in one district of Scotland. The zoning is classified as (*a*) normal, (*b*) simple reverse, and (*c*) oscillatory. Simple reverse zoning is associated with other differences in the zones which point to important time intervals between the growth of the zones. Oscillatory zoning is classified as oscillatory-normal and oscillatory-reverse, and attention is drawn to the occurrence of oscillatory-zoned crystals which show no general tendency toward either more calcic or more sodic composition. Distinction is drawn between the main zones and the thin shells of alternately more and less calcic composition within the main zone. The alternating composition of the thin shells is possibly the result of lack of balance between rate of growth of the crystal and rate of diffusion from the surrounding magma. Recurrence of calcic plagioclase in the inner part of main zones is explained as the result of irruption of hot magma into the crystallizing liquid, probably consequent on eruption of lava at higher levels. A.K.

BOOK REVIEW

Handbook of New Minerals, 1922–1932. O. M. SHUBNIKOVA AND D. V. YUFEROV. Edited and preface by A. E. Fersman, Lomonosov Inst. of Acad. of Sci. of U.S.S.R. State Sci.-Tech. Mining-Geol. Oil Pub. House, Leningrad, Moscow, Novossibirsk, 1934. 168 pp. Price 3 R 25 kopecks. The handbook on new minerals discovered in the last ten years contains short data about every mineral (its chemical composition, physical properties, paragenesis, occurrence, etc.). Besides new minerals, new data which make more precise the position of earlier discovered minerals are included. The minerals are arranged upon their chemical composition after the system of Dana. This gives the opportunity to compare new data on chemical analyses of minerals with mineral species already described. Distribution of the 360 new species by countries is as follows: U.S.A. 26, England (including Canada, India, and Australia) 14, Germany and Austria 12, France and Belgium 12, U.S.S.R. 11, Scandinavia 9, Slavonian countries (Poland, Czechoslovakia, etc.) 3, Italy 3, Japan 3, other countries (Hungary, Rumania, Bolivia, etc.) 6%. The contribution contains new minerals which have not been entered in Dana's Textbook of Mineralogy, 1922, and which have been carefully collected from the world literature published between 1922 and 1932. It may be recommended for translation in English.

S. I. PERKAL

BOOKS AND BULLETINS

Abstracts of current articles on geophysical prospecting. F. W. LEE. *Bur. Mines Periodical Service Rept.*, GA 62, 26 pp. (1934). 10¢. See also *Ceram. Abs.*, **13** [9], 242 (1934). R.A.H.

Indian Earths, Pottery Clays, and Refractory Materials. W. H. BATES. Mining and Geological Institute of India, Calcutta. *Ceram. Ind.*, **22** [7], 366 (1934). E.J.V.

Mineral Deposits. WALDEMAR LINDGREN. 4th ed. 930 pp., 333 figs. McGraw-Hill Book Co., New York and London, 1933. Price $6.50. Reviewed in *Econ. Geol.*, **29** [4], 401–406 (1934).—Mineral deposits are treated in accordance with a grouping based on the temperature and on the depth of their formation. The first two chapters are introductory, dealing with the distribution of elements, modes of concentration into mineral deposits, and fundamental physical and chemical conditions of mineral formation. Chapters III to VII deal with the movements and composition of underground waters, deposits made by springs at the earth's surface such as sulfur, quartz, opal, etc., and the relationship between mineral springs and ore deposits. Chapter IX discusses the relation of mineral deposits to metamorphism. Succeeding chapters consider the relation of magma to mineral deposits, folding and faulting, openings in rocks, form and structure of mineral deposits, ore-shoots, classification of mineral deposits, deposits formed by mechanical and chemical processes, deposits formed by concentration of substances contained in the rock itself, deposits formed by circulating waters, deposits due to concentration within rock of bodies foreign to the rock, deposits dependent upon the eruption of igneous rocks, deposits of native copper, mesothermal deposits, hypothermal deposits, metamorphosed sulfide deposits, pegmatite dike deposits, deposits formed by concentration in molten magma, oxidation and enrichment of ores, the relation of mineral deposition to mountain-building, and igneous intrusion. It is considered the best book on ore deposits in English in the opinion of the original reviewer. J.L.G.

PATENTS

Kaolin. WILLY HERTZSCH. Fr. 759,749, Feb. 7, 1934. Kaolin free from residues is obtained by dividing the mud of natural kaolin, by one or more centrifuging operations succeeding one another without interruption, into a fine mud free from residues and a residual mud. The muds are deposited on the bottom of a hollow rotary vessel and are pressed outward against holes in the periphery, the residual mud passing through lower relatively large holes, while the fine mud passes through upper smaller holes. (*C.A.*)

Process for working up cryolite. HUBERT SCHRANZ AND JOSEF KLOSE (Fried. Krupp Grusonwerk A.-G.). U. S. 1,966,649, July 17, 1934. A process for working up cryolite-bearing rocks and substances which, in addition to cryolite, also contain quartz and substances resembling cryolite, such as hagemannite, pachnolite, and thomsenolite comprises adding a salt of an alkali metal to render the hagemannite, pachnolite, and thomsenolite passive and alter the ordinary sequence of their natural wetting ca-

pacities, and froth-floating the cryolite by means of frothing agents, the hagemannite, pachnolite, and thomsenolite being left behind with the quartz in the rock as the tailings or unfloated residue.

Chemistry and Physics

Acid treatment of minerals containing alumina and the production of pure alumina. F. GEWECKE. *Chem. Fabrik*, **7** [21–22], 199–209 (1934).—The advantages and disadvantages of the alkaline and the acid methods are discussed. It is shown that for obtaining decomposition solutions free from or poor in iron, the treatment must be done in the presence of surplus alumina when using nitric acid. Difficultly soluble raw materials dissolve with increasing pressure and temperature. Iron-chrome-nickel alloys resist the action of nitric acid well even with raised temperature and pressure permitting the nitric acid to dissolve with difficultly soluble alumina silicates. The iron precipitation through hydrolysis and the durable derangement of equilibrium while the liberated acid (due to hydrolysis) is "taken up" by the surplus alumina are discussed in detail. It was found that the magnitude of this reaction of removal of iron depends on the basicity and concentration of the solution, the amount of iron present in the solution, and the temperature and time. Crystals of the composition $Al(NO_3)_3 \cdot 9H_2O$ were obtained from acid, neutral, and weakly basic aluminium nitrate solutions; from stronger basic solutions, crystals of uncertain composition were obtained. Aluminium nitrate crystals, free from iron, are obtained from aluminium nitrate solutions containing iron when the iron is present in colloidal form. The solubility of aluminium nitrate and iron nitrate in nitric acid of high concentration is discussed. The problem of thermal cleavage of aluminium nitrate was studied.
M.V.K.

Analysis of gas. PAUL WALTER. *Chim. & ind.* [Special No.], **31** [4 bis], 210–12 (1934).—A universal, automatic, and simple apparatus for a rapid analysis of fumes or industrial gases is described. M.V.K.

Apparatus for colorimetric researches of traces. A. A. GUNTZ. *Chim. & ind.* [Special No.], **31** [4 bis], 234–35 (1934).—To facilitate investigations and comparisons of weak colorations produced by colored reactions applied on traces of materials, a simple technique of observation with semicapillary tubes was evolved. This method permits quantitative estimation. M.V.K.

Binary system MnO–SiO_2. J. WHITE, D. D. HOWAT, AND R. HAY. *Jour. Roy. Tech. Coll.* [Glasgow], **3**, 231–40 (1934).—Heating and cooling curves were obtained by a differential method. Crucibles of Pt and Alundum were attacked by the melts, but Mo was satisfactory. The identity of solid phases was checked by optical methods. MnO melts at 1785°. SiO_2 melts at 1705°. Rhodonite melts incongruently to tephroite and MnO at 1280°. Tephroite ($2MnO \cdot SiO_2$) melts incongruently to MnO and SiO_2 at 1330°. The rhodonite-tephroite eutectic is at 37.5% SiO_2 and 1208°. SiO_2 does not dissolve in MnO. At 50 to 98% SiO_2 and above 1630°, 2 immiscible liquids are formed. (*C.A.*)

Calculation of the specific surface of a powder. H. HEYWOOD. *Proc. Inst. Mech. Eng.*, **125**, 383–459 (1933).—Fineness of a powder can be best expressed by means of the specific surface (S). An equation is derived for the determination of S which is applicable to most powders. The data required are the d, the sieve analysis, a volume constant determined by measurement, and a surface constant which can not be measured but can be indirectly obtained from tables given. Examples of the method of calculation, typical photographs, and values of the shape constants for particles of various materials are given.
(*B.C.A.*)

Complex calcium aluminates. JEANNE FORET. *Chim. & ind.* [Special No.], **31** [4 bis], 722–26 (1934).—Complex calcium silicates are tricalcium aluminates and calcium salts. They belong to one series of the salts, (1) $3CaO \cdot Al_2O_3 \cdot (A)_2Ca \cdot 10H_2O$, (2) $3CaO \cdot Al_2O_3 \cdot 3(A)_2Ca \cdot 30H_2O$. The conditions of their formation and the study of the univariant systems into which they change in the presence of their constituents are the object of this study.
M.V.K.

Contributions to the chemistry of germanium. I. R. SCHWARZ. *Berichte*, **62**, 2477–83 (1929). **II. Germanium nitrogen compounds.** R. SCHWARZ AND PETER W. SCHENK. *Ibid.*, **63**, 296–300 (1930). **III. Sulfo and pergermanates.** R. SCHWARZ AND H. GIESE. *Ibid.*, pp. 778–82. **IV. The system Na_2GeO_3–Na_2SiO_3 and the system K_2GeO_3–GeO_2.** R. SCHWARZ AND M. LEWINSOHN. *Ibid.*, pp. 783–87. **V. Complex compounds of germanium.** *Ibid.*, pp. 2428–32. **VI. Chemistry of germanium.** R. SCHWARZ, P. W. SCHENK, AND H. GIESE. *Ibid.*, **64**, 362–67 (1931). **VII. Organic compounds of germanium.** R. SCHWARZ AND M. LEWINSOHN. *Ibid.*, pp. 2352–58. **VIII. Germanium dioxide.** R. SCHWARZ AND ERNST HUF. *Z. anorg. allgem. Chem.*, **203**, 188–218 (1931). **IX. Germanates of the alkali and alkaline-earth metals.** R. SCHWARZ AND F. HEINRICH. *Ibid.*, **205** [1], 43–48 (1932).—Partial thermal analyses were made in the following systems: Na_2GeO_3–GeO_2 and K_2GeO_3–GeO_2. The melting temperatures of the compounds were determined. The hydrates of the alkali and alkaline-earth germanates were studied. Sodium metagermanate forms a hepta- and a hexa-hydrate. No hydrates of lithium metagermanate were found. Beryllium germanate forms two hydrates, a quadra- and penta-hydrate. No hydrates of strontium germanate were found. For Part X see *Ceram. Abs.*, **12** [1], 37 (1933). **XI. Other organic germanium compounds.** R. SCHWARZ AND W. REINHARDT. *Ber.*, **65**, 1743–46 (1932). **XII. Trichlor monogermanide and germanium oxychloride.** R. SCHWARZ AND F. HEINRICH. *Z. anorg. allgem. Chem.*, **209**, 273–76 (1932). L.T.B.

Designation of alkalis in chemical analyses of silicates. A. SIKORA. *Keram. i Steklo*, **10** [4], 20–21 (1934).—When calculating Seger formulas, the mean molecular weight between Na_2O and K_2O is used. This produces a considerable distortion in the knowledge of a given material or mass when the amount of alkalis exceeds 2 or 3%.
M.V.K.

Detection and measurement of longitudinal curvature

of small surfaces of any cross-section. H. E. GAUSS. *Jour. Sci. Instruments*, **11** [5], 157–62 (1934).—G. reviews methods of illumination of grooves for microscopic work and describes a "de-focussing" method for detecting and measuring undulations too small to be resolved. Formulas are derived for determining the curvatures from the observations made. Illustrated. J.L.G.

Determination of the plastic flow constants of mineral suspensions. M. P. VOLAROVICH AND D. M. TOLSTOI. *Jour. Phys. Chem.* [U.S.S.R.], **4** [6], 815–31 (1933).—A new design of a rotating cylinder apparatus was applied to the measurement of the plastic flow constants of aqueous clay suspensions. The outer cylinder containing the suspension was rotated by falling weights, while the inner cylinder, immersed in the suspension coaxially with the former, was kept stationary. Bingham's equation of plastic flow, $f - \theta = \eta \frac{dv}{dx}$, where θ is the yield value and η is a constant corresponding to the viscosity in Newton's equation, as integrated by M. Reiner and R. Riwlin for the case of coaxial cylinders, was checked, and proved to hold good within the range of angular velocities which could be covered in the apparatus. Within the limits of experimental error, the values of θ and η were found to be constant for a given suspension as tested with cylinders of various dimensions and at various angular velocities. Graphs representing the viscosity-concentration and the yield value-concentration relations were plotted for two grades of Russian clays. The character of the angular velocity-turning moment graphs was found to vary considerably for different grades of clay. At concentrations corresponding to equal yield values the more plastic the clay, the smaller was its viscosity. As a measure of plasticity the authors proposed the ratio $\frac{\theta}{\eta}$, corresponding either to equal concentrations of clay or to concentrations with equal yield values. (*J.S.G.T.*)

Dissolution of titanium compounds. P. RONCHESSE. *Ann. Soc. Sci. Bruxelles*, **B54**, 53–54 (1934).—The Ti-containing mineral (1 pt.) is fused with 4 pts. of dehydrated $Na_2B_4O_7$ and the melt taken up in 5 *N* H_2SO_4 warmed on a sand bath. After filtration and washing, no trace of Ti remains in the SiO_2 residue, whereas appreciable traces remain when the mineral is fused with $KHSO_4$.

(*B.C.A.*)

Effect of concentration on the rate of settling of suspensions. TADEUSZ PIECHOWICZ. *Przemysl Chem.*, **18**, 4–9 (1934).—In Robinson's equation (*Ceram. Abs.*, **5** [10], 329 (1926))concentration is expressed as a ratio of the volume of the solid to that of the suspension. This, introduced into the Stokes' equation, makes it $v = kr^2[(d_s - d_c)/z](1 - c)$. If equidistant cubical distribution of particles is assumed, concentration can be regarded as the variable. Then $z = \eta e/[l + Z(r + \alpha)]$, in which l is the distance between particles. Experiments were made with SiO_2 particles of diameters of 60, 35, and 15 μ in water, CO_2, $C_6H_5CH_3$, and CCl_4. The equation derived does not apply to concentrations lower than 0.035%. The function of heat of adsorption and surface tension should be introduced into the Stokes' law. The results of the analysis of sedimentation have value for comparison only when the concentration of the suspension is known. (*C.A.*)

Exact measurement of the specific heats of vanadium, niobium, tantalum, and molybdenum at high temperatures. F. M. JAEGER AND W. A. VEENSTRA. *Rec. trav. chim.*, **53** [6], 677–87 (1934).—The true specific heats, c_p, for these metals were determined as follows:

Va $0.119795 + 0.18375 \times 10^{-4}t + 0.20457 \times 10^{-7}t^2 - 0.108004 \times 10^{-11}t^3$,
Nb $0.06430 + 0.772766 \times 10^{-4}t + 0.234774 \times 10^{-8}t^2$,
Ta $0.033218 + 0.38066 \times 10^{-3}t + 0.19919 \times 10^{-7}t^2$,
Mo $0.061046 + 0.1232086 \times 10^{-4}t + 0.103636 \times 10^{-8}t^2$.

Bibliography. M.H.

Flow of gases at high temperatures through materials with dense structure. P. BREMOND. *Compt. rend.*, **196**, 1651–53 (1933).—When a gas flows through a wall of dense texture (fine pores) the output, according to Graham's law, is proportional to the difference in pressure between the two surfaces of the wall and inversely proportional to the square root of the absolute density of the flowing gas. At elevated temperatures, however, it was found that this law does not hold good; the amount flowing out through the wall is not proportional to the square root of the density but has a minimum which, for unity of pressure, occurred at 250°C for air, 240° for CO_2, 340° for H_2, 190° for SO_2, and 250° for city gas. The deviation from the law is ascribed to adsorption of the gas which varies with the temperature and modifies the dimensions of the capillary pores. M.H.

Grating constant of quartz. O. BERGQVIST. *Z. Physik*, **66**, 494–98 (1930).—The grating constant of a rock crystal was measured in the first and second orders with Cu $K_{\alpha 1}$ and Fe $K_{\alpha 1}$. The distance from slit to plate was 622.11 mm., the slit width, 0.02 mm. The X-ray tube operated at 35 kv. and 5 milliamperes; the exposure time was from 20 min. to 2 hr. No measurable plates were obtained in the third order in 3 hr. From the values in the first order, the higher-order results were calculated. A correction curve to the wave-length calculations is given for the anomalous dispersion of quartz. The results are d = 4246.02 Å, log $2d$ = 3.9290120. (*C.A.*)

Heat of wetting of soils. H. JANERT. *Z. Pflanzenernähr. Düngung. u. Bodenk.*, **19A**, 281–309 (1931).—Different methods of determining the heat of wetting of soils are given and compared with J.'s method. A close correlation between the heat of wetting and so-called "secondary" soil properties exists. Among the soil properties correlated with the heat of wetting were degree of lime saturation, ceramic properties, mechanical analyses, and hygroscopicity. It is concluded that the heat of wetting is a valuable aid in determining the physical properties of the soil as well as some of the chemical properties.

(*C.A.*)

Improved half-shade system for the detection of elliptically polarized light. LEIF TRÖNSTAD. *Jour. Sci. Instruments*, **11** [5], 144–47 (1934).—T. describes the application of the reflection theory of Drude to the examination of surfaces. Details are given for constructing the balanced ellipticity half-shade of mica sheets on the general principle of the Bravais biplate. The half-shade has a higher accuracy than the Babinet compensator. Illustrated. J.L.G.

Influence of various factors on the filtration velocities of kaolins and clays separated by flotation in solutions

of water-glass. N. A. HELD AND D. V. KORNILOV. *Inst. Mekhanicheskoĭ Obrabotki Poleznuikh Iskopaemuikh Mekhanobr* (*Inst. Mech. Treatment Ores*). *Repts. on Concn. of Ores*, No. 2, pp. 164–79 (1929).—The velocity of the filtration of clay is a function of its dispersion, a higher degree of the latter corresponding to a lower degree of the former. When increasing the degree of dispersion by the introduction in the suspension of a solution of water-glass the duration of filtration is prolonged. While a lowering of the dispersion is obtained by the introduction of salts of uni-, bi-, and tri-valent cations, *i.e.*, coagulants, the velocity of filtration is increased. The highest filtration velocity, other conditions being unchanged, is obtained when the clay suspension is coagulated with $AlCl_3$ and the lowest with HCl, the coagulation with $CaCl_2$ being intermediate. An increase in temperature accelerates filtration even with a coagulated suspension. The time the suspension is kept does not affect its filtering ability. The consumption of the coagulating medium depends upon the degree of dispersion of the clay; the consumption of the water-glass is measured in fractions of a percentage of the weight of the suspended clay. The experiments are described. (*C.A.*)

Measuring density. PAUL WALTER. *Chim. & ind.* [Special No.], **31** [4 bis], 218–19 (1934).—W. describes a small instrument permitting the immediate measurement of densities of solids without any calculations and measurements of weight or volume. M.V.K.

Method for concentrating kaolins and clays in the presence of electrolytes and protective colloids. N. A. HELD. *Inst. Mekhanicheskoĭ Obrabotki Poleznuikh Iskopaemuikh Mekhanobr* (*Inst. Mech. Treatment Ores*). *Repts. on Concn. of Ores*, No. 1, pp. 96–117 (1929).—According to the method described in detail, kaolin can be separated from admixtures by preparing a suspension which is of the required stability, adding to the suspension of the clay an amount of water-glass which would bring up the p_H of the suspension to about 10, and applying $CaCl_2$ for the coagulation of the kaolin. The theory of this phenomenon is discussed and the advantages of the method are brought out. The method can also be used for purifying clays. (*C.A.*)

Method for determining fluorine. H. HERLEMONT AND J. DELABRE. *Chim. & ind.* [Special No.], **31** [4 bis], 233 (1934).—The classical method for determining fluorine by attacking the products with sulfuric acid in the presence of silica always yields too low results because of the long time necessary to attack the silica. By replacing the latter with ferrosilicon rich in silicon, the results obtained are much more exact. M.V.K.

Method of determining the important physical constants of soil. H. JANERT. *Landwirt. Jahrb.*, **66**, 425–74 (1927).—J. presents a valuable study of soil constants, including the development of volume borers with comparative data. Methods of analysis for profile, soil surface, moisture, heat of wetting with water and CH_3COCH_3-water mixture, and formulas for determining hygroscopicity from heat of wetting are given. (*C.A.*)

Method for investigating clay. B. FARSKIĬ. *Keram. i Steklo*, **10** [1], 37–39 (1934).—A method, called method of fixed process, for investigating all the physical and chemical changes occurring during the various temperatures and different conditions of firing a clay sample, is described. Clays have a varying number of critical points connected with definite physical or chemical processes occurring in the clay in the limits of the whole interval of firing temperatures. These changes depend on (1) firing temperature, (2) firing time at a maximum temperature, (3) conditions of cooling, and (4) gaseous atmosphere of firing for the same sample of clay. The effect of the first three factors is related to a change of the critical points in the curve of linear volume changes, while changes in the gaseous atmosphere and in the chemical composition of the clay may change the number of critical points. Under the conditions of the usual methods of investigation with a limited number of temperature points, the critical points may be easily overlooked. M.V.K.

Method for measuring thermal conductivity of poor and medium heat-conducting materials. R. B. W. STEPHENS. *Phil. Mag.*, **15**, 857–80 (1933).—The method consists in determining the heat flow through a cylindrical tube filled with water and immersed in a water bath, the contents of both of which are thoroughly stirred. A formula is developed giving the thermal conductivity in terms of heat flow and dimensions of the cylinder. A measurement made in an ebonite cylinder gave results in close agreement with the standard values for this material. J.T.L.

Optical properties of calcium aluminates and ferrites. KEI-ICHI AKIYAMA AND GENTARO SAWAYAMA. *Bull. Waseda Applied Chem. Soc.*, **21**, 17–26 (in English 3–4 *A*) (1933).—$3CaO \cdot Al_2O_3$ was obtained by heating the raw mixture at 1500° for 2 hr. and cooling slowly. It was well sintered and showed a greenish white color, isotropic crystals with n 1.710. Two forms of $5CaO \cdot 3Al_2O_3$ (I) were known heretofore, but a new form, β-I, was found which was made by heating the raw mixture at 1450 to 1470° for 2 hr. and cooling slowly. It was well fused with reddish yellow color and contained no free CaO or Al_2O_3. The double refraction was very weak and the interference color was gray of the 1st order. The crystal showed gridiron twinning, wavy extinction, and parallel extinction and was optically uniaxial and negative n 1.6152 $< n_1 < n_2 <$ 1.6175, density 2.70. Methods of preparation and optical properties of α- and α'I, CaO Al_2O_3, $3CaO \cdot 5Al_2O_3$, $CaO \cdot Fe_2O_3$, $2CaO \cdot Fe_2O_3$, and $4CaO\ Al_2O_3 \cdot Fe_2O_3$ are given. (*C.A.*)

Particulars in the field of silicate research. W. WEYL. *Chem.-Ztg.*, **58** [28], 285–87 (1934).—Details are given of the method of static investigations of silicate equilibria, determination of the melting point, and diagrams of binary and ternary systems. The difficulties encountered in the study of silicates and the work at the Kaiser Wilhelm Institute for Silicate Researches are discussed. M.V.K.

Permanent magnetization of fired earths. E. THELLIER. *Compt. rend.*, **197** [23], 1399–1401 (1933).—When fired earths (brick, pottery) are cooled in a magnetic field they become weakly magnetized though fairly stable. Experiments have shown that the magnetization depends to a great extent on the firing temperature; a repeated firing destroys magnetization by previous firing, apparently even at lower temperature. The permanent magnetization produced during firing in a uniform magnetic field is

also uniform and depends on duration of firing, temperature, and furnace atmosphere. M.H.

Precipitation conditions of zinc sulfide and hydrated alumina and a process for the gravimetric separation of zinc from aluminium. J. N. FRERS. *Z. anal. Chem.*, **95** [1-3], 1-36; [4-6], 113-42 (1933).—From the standpoint of the p_H range of the precipitation region, the separation of the bivalent and trivalent metals of the ammonium-sulfide group by hydrolysis was considered of interest. An ammonium sulfate method for the individual determination of zinc was developed. The dependence of the zinc sulfide precipitation on different conditions was studied. The concentration of the H-ion is the chief regulating principle in zinc-sulfide precipitation. This is much greater than expected according to the law of mass action. It depends (as stated by Glixelli), on the fact that no true equilibrium applies, but that the rate of reaction, which is retarded by the H-ions, plays an important rôle. Zinc sulfide and filter paper accelerate the precipitation catalytically. The effect of neutral salts on the precipitation was studied. By potentiometric measurements it was determined that it is not the Zn-ion concentration that affects the precipitation in such a decisive manner. New directions for the individual determination of aluminium are based on studies of (1) suitability of the indicators, methyl red, phenol red, and phenophthalein, (2) solvent action of the wash water, (3) effect of ammonium chloride, ammonium nitrate, and ammonium sulfate, and (4) ignition and weighing of the porcelain crucible and the alumina. Alumina ignited at 1200° is no longer hygroscopic. This determination was made on the basis of a comparison of the speed of increase in weight of porcelain crucibles containing alumina. The transition point of the γ-oxide to corundum lies at 1010 ± 5°C. A simple and exact method for the separation of zinc from aluminium was determined. E.J.V.

Properties of silver silicate. B. BOGITCH. *Compt. rend.*, **198** [22], 1928-29 (1934).—Experiments on the causes of the yellow coloration of glass often ascribed to Ag showed that Ag is not in colloidal state and that discoloration is caused by the formation of silver silicates; colloidal silver and an aqueous solution of Ag render the glass a milky white. M.H.

Quartz as a standard for accurate lattice-spacing measurements. A. J. BRADLEY AND A. H. JAY. *Proc. Phys. Soc.* [London], **45**, 507-22 (1933).—Quartz was tested as a standardizing substance for accurate lattice spacing determinations by the powder method. Sharp and intense reflections of the resolved Cu K_α doublet were obtained in the higher orders. If Bergquist's value is assumed for d_{100} (4246.02 Å) the following values are obtained for clear colorless quartz: a = 4902.9 Å; c = 5393.3 Å; c/a = 1.10002 ± 0.00004. For 10 specimens of various colorations, d_{100} at 18° lay between 4245.9_8 and 4246.3_0 Å. A table of diffraction angles for quartz and 15 references are given. (*C.A.*)

Reaction regions. X. Reaction regions Fe-S-SiO_2, Fe-Mg-S, and Fe-Al-S. W. P. JORISSEN AND B. L. ONGKIEHONG. *Rec. trav. chim.*, **45**, 540-44 (1926).—The mixtures for which explosive reactions in powders similar to explosions in gases may occur were established; results are given in tables and charts for different mixtures. **XII. Reaction space Fe-Mg-Al-S.** *Ibid.*, pp. 849-53.—Charts and tables for upper and lower limits of explosive mixtures are given. **XIV. A closed reaction region.** W. P. JORISSEN AND C. GROENEVELD. *Ibid.*, **46**, 369-72 (1927).—If a mixture of Al turnings or powder, S, and fine sand is covered with a thin layer of Mg powder and then ignited the reaction will be propagated through the whole mass for mixtures of suitable compositions which were determined experimentally for different binary and ternary mixtures. The inactive region is illustrated in a ternary diagram Al-S-SiO_2. **XVII. Reaction regions in which a dichromate is the substance supplying oxygen.** W. P. JORISSEN AND G. M. A. KAYSER. *Ibid.*, pp. 885-90.—The reaction zones of K_2Cr_2O-S-Fe, ammonium dichromate-potassium chloride-potassium sulfate, ammonium dichromate-S-Fe, ammonium dichromate-S-Fe-silica, were established. **XXI. Al-MoO_3-CaF_2, Al-MoO_3-CaF_2, Al-S-B_2O_3, and Si-CuO-PbO.** W. P. JORISSEN AND A. H. BELINFANTE. *Ibid.*, **51**, 853-67 (1932).—The regions of the ternary diagram in which reactions are propagated in mixtures of these powdered substances are investigated and the results are given in tables. M.H.

Reaction between solids. ALVARO ALBERTO. *Rev. soc. brasil. chim.*, **4**, 202-18 (1933).—Discussion and bibliography are given. (*C.A.*)

Reactions in solids. ROLAND WARD. *Trans. Ill. State Acad. Sci.*, **25**, 167-69 (1933).—A review of the work of van Liempt, Langmuir, Hume and Colvin, Tammann, Hedvall, Jander, and others is given. Reaction is initiated by deformation of the crystals through grinding, followed by rearrangements to form more stable products. Higher temperatures increase the diffusion velocities at the crystal interfaces. (*C.A.*)

Reflecting power of powders in the far infra-red region. CARROLL W. BRYANT. *Jour. Opt. Soc. Amer.*, **24** [5], 139-42 (1934).—The dependence of the reflecting power of powdered quartz and marble upon pressure is shown in a quantitative way for the spectral band of 80 to 150. R.H.H.P., JR.

Researches on indifferent electrodes. I. Potentiometric titration of calcium. C. A. NIERSTRASZ AND H. J. C. TENDELOO. *Rec. trav. chim.*, **53** [6], 792-97 (1934).—The potentiometric titration of Ca can be successfully carried out with reference electrodes of the type M_1-Cu oxalate-Ca oxalate, where M_1 can be Ag, Au, or Pt. The procedure is described in detail. M.H.

Si_4O_8 chains in space groups V_h^{16} and C_{2h}^5. TEIICHI ITO. *Proc. Imp. Acad.* [Tokyo], **9**, 528-30 (1933).—The compound, $HNaBeSi_2O_6$ exists as epididymite in rhombic form and as eudidymite in monoclinic form. Chains are built up of linked tetrahedra of Si and O atoms of composition Si_4O_7. The chains are joined into a sheet by a sharing of half the number of O atoms on the fringe by adjoining chains, by placing centers of symmetry on those points lying midway between every two atoms on one of the O layers of the chain. Blocks joined at the edges might represent a sheet. In three dimensions, these should be one above the other but in two forms: (1) the successive sheets are parallel to each other; (2) the successive sheets are in the mirror-image relation. If 1.3 Å is assumed as the O-ionic radius with close packing, two

arrangements containing 24Si and 56O atoms are obtained; arrangement (1) corresponds to C_{2h}^{5} (monoclinic) and (2) to V^{16} (rhombic). Epididymite corresponds to (2). See also *Ceram. Abs.*, **12** [10–11], 402 (1933). (*C.A.*)

Sodium silicates. ANON. *Ind. chimique*, **21** [244], 335 (1934).—A general discussion of the properties of various sodium silicates is given. M.V.K.

System of elements. I. Vector model of the free atom. A. J. RUTGERS. *Chem. Weekblad*, **30** [37], 602–606 (1933).—The theories of Rutherford and Bohr on the construction of the atom and the importance of Planck's quantum theory in the emission of spectral radiation are explained and illustrated by the example of several elements. **II. Notes on the periodic system.** C. J. GORTER. *Ibid.*, **30** [39], 632–35 (1933).—Brief historical remarks on the development of ideas on elements in Greek philosophy and the final periodical system as we have it now with its arrangement as expression of chemical and physical properties are presented. **III–IV. Explanation of chemical properties on the basis of the atomic theory.** *Ibid.*, **30** [40], 642–46; [41], 654–57 (1933).—The chemical properties of the elements are explained on the basis of the atomic theories developed in Part I; arrangement and distribution of electrons in the atom are tabulated. **V. Methods for investigating the atomic nucleus.** *Ibid.*, **30** [42], 671–74 (1933).—The determination of protons and electrons and of isotopes by spectrographic methods and the possible arrangement of nuclei according to theories of Goudsmit and Fermi are discussed. The differences in arrangement in pure and mixed elements are explained. **VI. Structure of atomic nuclei.** A. J. RUTGERS. *Ibid.*, **30** [43], 682–84 (1933).—The structure of the nucleus of atoms is treated and R. shows how the impact of α-particles can give information as to the number of neutrons and protons in the atomic nucleus. The modern physical views are discussed and a table of the structure of the nucleus for the first 36 elements is given. It has not been possible so far to observe positive electrons because they probably have only a short life outside of the nucleus as they combine with an electron and then can disappear as γ-quanta according to Dirac's theory. M.H.

Two variations of the powder method of X-ray analysis of crystals. J. P. BLEWETT. *Jour. Sci. Instruments*, **11** [5], 148–50 (1934).—B. describes two variations of X-ray analysis by the powder method which give greater intensity and the attainment of diffraction angles at almost 0°. Illustrated. J.L.G.

Volatility of SiO_2 in supercritical steam. C. J. VAN NIEUWENBURG AND H. G. BLUMENDAL. *Rec. trav. chim.*, **53** [4], 476 (1934).—The authors repeated their experiments to clear up a doubt expressed by another investigator, but confirmed their first result that silicates are formed at temperatures of supercritical steam, and that this formation is clearly a function of the duration of the experiment. They conclude that the formation is a pneumatolitic synthesis and not a transient hydrothermal condition. M.H.

DIAGRAMS

Composition-Temperature Phase Equilibrium Diagrams of the Refractory Oxides (Four Plates). Revised and redrawn by ROBERT B. SOSMAN AND OLAF ANDERSEN. Price $2.00 a set. Research Laboratory, United States Steel Corp., Lincoln Highway, Kearny, N. J. Plate 1 gives the liquidus surface of the system MgO–Al_2O_3–SiO_2, Plate 2, that for the system CaO–Al_2O_3–SiO_2, Plate 3, that for CaO–MgO–SiO_2, and Plate 4, that for the system CaO–MgO–Al_2O_3. The base of each diagram is a 500-mm. equilateral triangle divided to 5 mm. (1% in composition), accurate in the original to 0.1 mm. The base is blue, temperature contours are in green, compositions (including solid solutions) are in red, and boundary curves and primary phases in black. The sheets are of map paper, 19 by 24 inches. The diagrams permit interpolation to 0.1%.

BOOK REVIEW

Chemical Analysis of Chromic Irons and Articles from Them. A. V. TERESHTSCHENKO, O. M. MARGULIS, AND E. M. SKIBINA. 30 pp. Ukrainian Sci. Research Inst. of Refractory and Acid-Resistant Materials. State Sci.-Tech. Pub. House of Ukraine, Kharkov, 1934. Price 1 R 50 kopecks. S. I. PERKAL

BOOKS AND BULLETIN

Adsorption of Gases by Solids. S. J. GREGG. Methuen & Co., London. Price 2s 6d. 120 pp. Reviewed in *Mech. World*, **96** [2480], 38 (1934).—Concentration of a gas at an interface between a solid and a gas is higher in the immediate vicinity of the solid than it is in the free space beyond. The mass of gas actually present within the sphere of action of the solid less the mass which would be present if the solid exerted no action is the amount of adsorption. The characteristics of adsorption are discussed. Theories and heat of adsorption, adsorption forces, properties of the adsorbed layer, structure of the adsorbent surface, and activated and chemical adsorption are treated. E.J.V.

Technical Gas Analysis. LUNGE AND AMBLER. Gurney and Jackson, London. 414 pp. Price 21s. Reviewed in *Can. Chem. Met.*, **18** [7], 39 (1934).—This thoroughly revised work describes all the former methods of gas analysis, with particular reference to the processes for important gases. Special sections are given to analysis of flue gases and physicochemical applications. E.J.V.

Vitrification. JOHN G. STEIN & CO., LTD. *Refrac. Bull.*, No. 21 (Sept., 1933).—A discussion of the transformations taking place during the process of vitrification is presented. A table shows the changes brought about by vitrification in refractories, porcelain, and commercial glasses. M.V.K.

PATENTS

Barium. GOSUDARSTRENNOJI VSESOJUZNOJE OBJEDINENIJE ELEKTRO-SLABOTOCHNOJ PROMYSHLENNOSTI (V.E.S.O.). Ger. 593,692, March 1, 1934. Pure Ba is prepared by the thermal reduction of $mBaO{\cdot}nAl_2O_3$, prepared by fusing together Ba $(OH)_2$ and $Al(OH)_3$ *in vacuo*. (*C.A.*)

Cobalt titanate and method of making. W. J. CAUWENBERG (Titanium Pigment Co., Inc.). U. S. 1,969,061, Aug. 7, 1934. A method of making cobalt titanate com-

prises mixing a neutral titanium oxide pulp and cobaltous carbonate, drying the mixture, and calcining the dried mixture.

Means for producing tin oxide. ERNST FELDMANN. U. S. 1,968,933, Aug. 7, 1934.

Production of titanium pigments. TITAN CO., INC. Brit. 413,915, Aug. 1, 1934.

Sodium silicate. HENKEL & CIE. G.M.B.H. (Franz Albertshauser, inventor). Ger. 592,292, Feb. 5, 1934. A solution or melt of Na metasilicate is caused to crystallize, and as soon as crystallization has begun a solid hydrated Na water-glass containing more SiO_2 than Na_2O is added. The mixture is allowed to set and the product is ground. A water-soluble product stable to storage is obtained. The Na metasilicate solution may be prepared in the process from commercial Na water-glass and NaOH. Details are given. (*C.A.*)

Zirconia. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY, ET CIREY (Henri George and Roger Lambert, inventors). Fr. 762,066, April 3, 1934. Zircon is decomposed by fusion into pure crystallized zirconia and a vitreous SiO_2 which is removed by the action of HF or by the addition of oxides such as Al_2O_3, CaO, and MgO. (*C.A.*)

General

Atmospheric dust recorder. WILLIS G. HAZARD AND PHILIP DRINKER. *Jour. Ind. Hyg.*, **16** [3], 192–96 (1934).—A recording meter for atmospheric dusts is described. Dust is continuously impinged on a slowly moving, transparent film, and simultaneously the density of the deposit is recorded by photoelectric means. The original dust sample may be preserved indefinitely. The principal advantages of a recorder as opposed to a "grab" sampler are that it furnishes a permanent, long-period record, indicating relatively rapid variations in the concentration of atmospheric dust. Furthermore, after suitable calibration, the record may be interpreted directly by an unskilled observer. Illustrated. E.J.V.

Ceramic industry of Australia. E. T. MCPHEE. *Official Yearbook of Australia*, **26**, 648–73 (1934).—In 1932 there were 313 factories making brick, pottery, glass, etc. Of these, 131 were in New South Wales and 92 in Victoria. Employees numbered 5200 of whom 74 were children. Salaries and wages amounted to £873,244, females getting £25,226, and managers and office staffs £183,655 (females £11,991). The value of power, fuel, and light used was £277,623; of raw materials £513,719; of land and buildings £1,992,755; of plant and machinery £1,974,507; and of the finished output £2,257,434. H.H.S.

Ceramics of yesterday and today at World's Fair. ANON. *Ceram. Ind.*, **22** [7], 354–61 (1934).—A description of the many exhibits of ceramic products on display at the 1934 Century of Progress is presented. Illustrated. E.J.V.

Fundamentals of flotation in the light of recent research. Frothing. GUIDO R. M. DEL GIUDICE. *Eng. Mining Jour.*, **135** [4], 152–55 (1934).—Illustrated. J.L.G.

Irish Free State ceramic industry. ANON. *Times Eng. Supp.*, **34**, 259 (1934).—The manufacture of porcelain, china, delft, and earthenware is to be undertaken at Arklow. The industry will be adequately protected by tariffs and will enjoy a virtual monopoly. H.H.S.

Manufacture of ultramarine. J. B. REMINGTON. *Paint Manuf.*, **3**, 222 (1933); abstracted in *Ind. chimique*, **21** [242], 187 (1934).—Ultramarine is produced by two methods, in a muffle kiln and in a crucible. The raw materials used are clay, sodium carbonate, Glauber salt, quartz, silica, or kieselguhr, sulfur, colophane, and coal or resin. The characteristics that these materials must possess for the manufacture of ultramarine are described. Formulas for different ultramarines having various colorations and which must be treated at different temperatures are discussed. Details of manufacture are given. M.V.K.

Minerals used in the pulp and paper industry in Canada. HORACE FREEMAN. *Can. Mining Met. Bull.*, No. 268, pp. 398–404 (1934).—Requirements as to quality and volume and sources of supply are discussed for the following minerals: china clay, talc and soapstone, bauxite, limestone and lime, coal, sandstone, salt cake, and pyrite. G.M.H.

Outstanding developments in ceramics in 1933. J. G. PHILLIPS. *Jour. Can. Ceram. Soc.*, **3**, 7–14 (1934).—A résumé of the technological and industrial developments that occurred in the field of ceramics during 1933 is given. J.G.P.

Permeable-pressed ceramic bodies. A. E. R. WESTMAN. *Jour. Can. Ceram. Soc.*, **3**, 32–33 (1934).—A résumé is given. J.G.P.

Prevention of silicosis. P. S. HAY. *Iron & Coal Trades Rev.*, **127**, 713,758 (1933).—A review is presented of practical methods of preventing silicosis, mainly with reference to the mining industry. The principal factors governing the development of silicosis are (1) concentration of dust in the atmosphere, (2) size of the particles, (3) time of exposure to the dust, and (4) general physical condition of the worker. It is only the extremely minute dust particles (0.5 to 7 microns in diameter) which are considered dangerous. Three instruments for determining the dust concentration in the atmosphere are described briefly: Owens dust-catcher, Kotze konimeter, and the Zeiss konimeter. The use of water as a preventive measure has been shown to be quite useless. Up to the present time, most dust respirators have been found to be generally unsatisfactory, but an almost ideal respirator has been developed by the Department of Scientific and Industrial Research. It is ingenious in design, quite comfortable to wear for long periods, light in weight (4 oz.), and has a remarkably high filtering efficiency with dust particles in the dangerous-size range and a very low resistance to breathing. The protection of drillers in mines by the use of dust traps and filters is discussed. (*T.C.S.E.*)

Quantitation of impinger dust samples by dark-field microscopy. THEODORE HATCH AND C. L. POOL. *Jour. Ind. Hyg.*, **16** [3], 177–91 (1934).—A minimum size of dust particle capable of producing silicosis has never been demonstrated by direct experiments. Evidence available does not warrant the conclusion that it is close to the

limit of visibility of the light-field microscope used at the present time in the quantitation of impinger dust samples, particularly since about 90% of the particles in such samples are shown to be submicroscopic in size and definitely of industrial origin. The additional particles are revealed under a dark-field microscope ("Dissecting" condenser, 16 mm. objective, and 30× ocular), having a limit of visibility slightly over 0.1 micron. For the industrial samples investigated, the ratio of counts obtained with this optical system and the present light-field microscope varies with particle size from 2.0 to 34; the median value is 10, and the probable error ±3. For average plant conditions, the dark-field count appears to give, with much greater facility, as good a measure of the dust hazard as the present light-field technique, and for extremely fine dusts it is not justifiable to ignore the greatly increased dark-field count. The ratio of counts obtained with two dark-field systems possessing different limits of visibility (Zeiss "Dissecting" and "Plankton" condensers) is suggested as an approximate index of particle size of industrial dusts. E.J.V.

Relative floatability of silicate minerals. JOHN MARK PATEK. *Mining & Met.*, **15** [332], 358 (1934).—The relative floatability of twenty silicates representing a wide variety of common types was determined by laboratory flotation tests. A study which involved the recording and interpretation of contact angles was made to discover the causes for differences in the floatability of silicate minerals. It was concluded that the fatty acid collecting agent probably concentrates at silicate surfaces because of (1) the formation of insoluble metal soaps which depend on chemical reactions between the polar groups of the fatty acid molecules and the mineral, and (2) the concentration or adsorption of the nonpolar groups of the fatty acid at the mineral surfaces because of the mutual insolubility of both the nonpolar groups and the solid. The latter phenomenon is considered the cause of the high floatability of unusually insoluble minerals, such as cassiterite, to which is attributed the property of low wettability. It was found that the comparative wettability of silicates varies inversely as their density. Their tendency to form insoluble soaps is determined by the ratio of the number of valences of the atoms or atomic groups which form insoluble soaps to the number of valences of those which do not. For the purpose of predicting silicate mineral floatability, a formula was evolved based on density and the so-called valence ratio. E.J.V.

Scientific precious stones and their manufacture. F. RAVIER. *Chim. & ind.*, **31** [5], 1031–39 (1934).—Precious stones, called scientific, have pure crystallized alumina as a base; the alumina is obtained by fusing ammoniacal alum. The production of ammoniacal alum ($(SO_4)_2Al_2$, SO_4Am_2, $24H_2O$), the use of various pigments, and the grinding and polishing of the precious stones obtained are described in detail. M.V.K.

Silicosis. MARK A. DALY. *Bull. Amer. Ceram. Soc.*, **13** [8], 213–14 (1934).

Silicosis. BENJAMIN F. TILLSON. *Eng. Mining Jour.*, **135** [6], 262–64 (1934).—T. considers the economic aspects of silicosis. Under cost of compensation he explains that the total cost may be four times the compensation award. This includes losses due to absenteeism, labor turnover and lowered efficiencies of labor, and plant operations. Suits are being brought for $100,000 per individual affected and awards as high as $28,000 have been made. No states have silicosis compensation laws but six have occupational disease legislation which covers silicosis. The losses in the U. S. and their effect in increasing the cost of silica grinding are considered. The high cost of insurance for silicosis is explained. Rights under the standard policy are discussed. Two court decisions have relieved the insurance companies from liability for silicosis compensations under such policies. The insured should study any policy containing an endorsement to cover occupational diseases to see if it meets his need, as some such clauses have been claimed not to cover silicosis compensation. See also *Ceram. Abs.*, **13** [8] 227 (1934). J.L.G.

Synthetic precious stones. H. ESPIG. *Chem.-Ztg.*, **58** [13], 133–34 (1934).—The most widely known synthetic precious stones are the ruby and the sapphire; the coloring is produced by chrome or titanium and iron, as in the corresponding natural stones. The crystallized aluminium oxide, the α-corundum, as it is present in sapphire, can be colored various colors. Spinels similar to natural spinels are also produced. They contain aluminium and magnesium oxides and are colorless, but can be variously colored. The characteristics, application, and means of detection of synthetic stones are discussed. Bibliography. M.V.K.

BOOK REVIEW

Standards Yearbook, 1933. Compiled by the BUREAU OF STANDARDS. 255 pp. Price $1.00 from Supt. of Documents, Washington, D.C. This volume contains outlines of the standardization activities and accomplishments not only of the Bureau of Standards and other agencies of the Federal Government and the States and counties but also those of national technical societies and trade associations. There is also presented a picture of the standardization movement in various fields of industry conducted by certain national and international agencies. Special attention has been paid to the current programs of American standardizing agencies and their accomplishments to date, with special reference to the year just past, without reproducing the information concerning their methods of appointing standardizing committees, authority bestowed upon these committees, and their functions and procedure which may be found in previous editions of the Yearbook. An attempt has been made in this issue to include in the outlines such methods as are employed by these agencies for making their standards and specifications effective throughout industry and to determine whether or not their requirements are being complied with. R.A.H.